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COMPREHENSIVE SITE ASSESSMENT PHASE II FIELD INVESTIGATION REPORT VOLUME I (Text and Appendix A through D)

Wilmington Facility
Wilmington, MA

Olin Corporation

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CONESTOGA-ROVERS & ASSOCIATES

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EXECUTIVE SUMMARY

A Phase II Comprehensive Site Assessment (CSA) program was designed and implemented by Conestoga-Rovers & Associates (CRA), on behalf of Olin Corporation (Olin), at the former production facility (Facility) located at 51 Eames Street, Wilmington, Massachusetts. The objective of the CSA was to conduct a systematic investigation and assessment of the Facility to characterize the type and quantity of oil or hazardous materials released at or from the Facility in order to characterize and evaluate the risk of harm, if any, that the Facility poses to health, safety, public welfare and the environment. This report, prepared by CRA, presents a summary of the data collected, its evaluation and conclusions drawn from the Phase II CSA activities conducted at the Facility. A risk assessment for the Facility, based on the CSA data, has been prepared by Asea Brown Boveri (ABB) and is presented under separate cover.

The Facility, from its construction in 1953, historically manufactured chemical blowing agents, stabilizers, antioxidants and other specialty chemicals for the rubber and plastics industry. Prior to 1970, all liquid wastes generated at the Facility were discharged into a series of unlined pits in the central portion of the Facility. In 1970, a neutralization system including two lined lagoons was completed. Acidic waste streams were neutralized with lime and discharged to the lined lagoons with the supernatant pumped through a clarifier before discharge. The solids (calcium sulphate) from the lined lagoons were periodically dredged from the lined lagoons and landfilled on the southwest corner of the Facility (Sulphate Landfill). The lined lagoons were removed and the Sulphate Landfill was closed in 1986 when operations at the Facility ceased.

Annual monitoring performed at the Facility in 1990 indicated that past operations and disposal practices at the Facility had resulted in off-site groundwater contaminant migration to the west of the Facility. In response to these data, Olin retained CRA to prepare and complete a Phase II Comprehensive Site Assessment for the Facility.

The CSA identified the following geologic units at the Facility, in descending order of age, as glacial outwash, glacial ice contact deposits; glacial till, and fine grained sedimentary gneiss. The glacial ice contact deposits and glacial outwash function as the single, principal hydrostratigraphic unit in the area of the Facility. The uppermost fractured portion of the bedrock is considered part of this flow system. Below the upper fractured bedrock, little groundwater is transmitted along small fractures and joints.

The Facility and surrounding area encompasses portions of two hydrogeologic basins with the divide separating these two basins located west and north of the Facility. East of the divide, the general groundwater flow is from the northwest to southeast across the main part of the Facility and ranges between 10 feet and 325 feet per year. West of the divide, the groundwater flow ranges between 10 feet to 425 feet and is directed to the west into the main portion of the regional aquifer. Closely paralleling the groundwater divide is a surface water divide separating the watersheds of the Ipswich and Aberjona Rivers.

A dense groundwater plume, approximately 20 feet thick beneath the Facility, is observed from the central portion of the Facility to just beyond Highway 38 (Main Street) to the west, edges east just off the Facility boundary to the East Ditch and edges just off the southwest of the Facility in the vicinity of the Sulphate Landfill. Frequently detected Facility-related compounds detected in the groundwater include Volatile Organic Compounds (VOCs), Semi-Volatile Organic Compounds (SVOCs) and inorganic compounds. The VOCs and SVOCs are mainly limited to the Facility. The inorganic compounds ammonia, chloride, chromium and sulphate are the major compounds associated with the off-site dense plume.

Three factors believed to have had the major influence over migration of the dense contaminant plume in the aquifer, are the slope of the bedrock surface; the hydraulic forces generated from recharge of the contaminants; and the dilution effects at the plume edge which control pH.

The organic contaminants found in the groundwater in the central portion of the Facility are most likely attributable to three sources: the discharge of yard and process spills and oily wastes to Lake Poly, the disposal of organic wastes to the unlined pits, and the disposal of drums containing organic compounds beneath the ground surface.

The inorganic contaminants found in the groundwater are most likely attributable to wastewater which was directed into a series of unlined pits and the unlined Lake Poly located in the central portion of the property.

The organic contaminants found in the area of monitoring well GW-49 east of the Facility, indicate an off-site source of organic contaminants is present, since no apparent correlation can be made between the Facility-related organic compounds and the organic compounds detected in well GW-49.

There are three areas at the Facility which exhibit evidence of buried drum waste, miscellaneous waste and visibly contaminated soils. Materials within the test pits of the three areas have been identified as Opex, Kempore, Phenolic resins, and Plant B material (diphenylamine). Organic compounds B2EHP, NNDPA and NNDNPA and inorganic compounds ammonia, calcium, chloride, chromium, iron, potassium, sodium and sulphate are the major compounds detected in the drums and/or soil samples.

The highest concentrations of contaminants in the surface and subsurface soils across the Facility were detected in the vicinity of former Lake Poly. Detected compounds include VOCs, SVOCs and inorganics.

The highest concentrations of contaminants in surface water and sediment were generally detected in the West Ditch and decreased across the Facility. Detected compounds include VOCs, SVOCs and inorganics. Contaminants found in the surface water and sediments are most likely contributable to discharges from process areas into Lake Poly which emptied into the West Ditch.

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1.0 INTRODUCTION

This report, prepared by Conestoga-Rovers & Associates (CRA), on behalf of Olin Corporation (Olin), presents a summary of the data collected, its evaluation and conclusions drawn from the Phase II Comprehensive Site Assessment (CSA) activities conducted at the Wilmington, Massachusetts Facility (Facility) currently owned by Olin. A risk assessment for the Facility, based on the CSA data, has been prepared by Asea Brown Boveri (ABB) and is presented under separate cover in a report entitled "Comprehensive Site Assessment, Phase II Risk Assessment Report, Wilmington Facility, Wilmington, Massachusetts, Olin Corporation" (CSA Phase II Risk Assessment Report). The location of the Facility is shown on Figure 1.1.

Past operations and disposal practices at the Facility have resulted in groundwater contamination beneath the Facility. In 1986, Wehran Engineering Corp. prepared, on behalf of the Massachusetts Department of Environmental Protection (DEP), a Phase I Facility Inspection Report. Subsequently, the Facility was classified by the DEP as a non-priority disposal site. A waiver of certain intermediate stages of approvals was obtained for the site under the Massachusetts Contingency Plan (MCP) in July of 1989.

Olin has performed annual monitoring at the Facility since 1986. Wells installed in late 1989 and monitoring conducted in 1990 indicated that off-site groundwater contaminant migration had occurred to the west of the Facility.

In response to these data, Olin retained CRA to prepare a Work Plan for a Phase II Comprehensive Site Assessment (CSA). Subsequent to completion of the Phase II CSA Work Plan, Olin retained CRA to carry out field activities required to complete the CSA and ABB to complete the risk assessment as part of the CSA. CRA commenced the CSA field activities in December 1990 and completed all CSA field activities in May 1993. All work was conducted in accordance with the "Work Plan, Comprehensive Site Assessment (CSA), Wilmington Facility, Wilmington, Massachusetts, Olin Corporation", originally prepared by CRA in October 1990 and revised and finalized by CRA in March 1991. The preparation of this CSA Phase II Field Investigation Report and the CSA Phase II Risk Assessment Report represents the culmination of the Phase II CSA.

The objective of the CSA was to conduct a systematic investigation and assessment of the Facility to characterize the type and quantity of oil or hazardous materials released at or from the Facility in order to characterize and evaluate the risk of harm, if any, that the Facility poses to health, safety, public welfare and the environment. The CSA provides the data necessary to be used in developing remedial response alternatives as required by 310 CMR 40.546, Phase III Development of Remedial Response Alternatives and the Final Remedial Response Plan. The CSA also provides the corresponding data under the National Contingency Plan (NCP), 40 CFR Part 300. In November 1992, Olin retained BCM Engineers from Plymouth Meeting, PA to prepare the Phase III Development of Remedial Response Alternatives Report. The preparation of the Phase III Remedial Response Alternatives Report is currently in progress.

1.1 CSA PHASE II FIELD INVESTIGATION REPORT ORGANIZATION

The CSA Phase II Field Investigation Report is organized in the following major sections and supporting appendices:

- Section 1.0 presents the introduction to and organization of the CSA Phase II Field Investigation Report;
- Section 2.0 presents background information including Facility history and a summary of its historic data base;
- Section 3.0 discusses the regional characteristics of the Wilmington area including topographic, climatic, geologic and hydrogeologic information;

- Section 4.0 presents a summary of the field activities completed as part of the CSA;
- Section 5.0 presents a summary of physical characteristics of the site (Facility);
- Section 6.0 presents a characterization of contamination at the Facility;
- Section 7.0 provides summary and conclusions based on the CSA Phase II *Field Investigation; and*
- Section 8.0 provides recommendations for future actions.

As discussed above, in Section 1.0, a risk assessment, based on the CSA data, has been prepared by ABB and is presented under separate cover.

2.0 BACKGROUND INFORMATION

2.1 FACILITY LOCATION AND SURROUNDING LAND USE

The Wilmington, Massachusetts Facility (Facility) occupies a 53-acre site located at 51 Eames Street, Wilmington, Massachusetts. The Facility is bounded on the east by the Boston and Maine railroad tracks, on the south by the Woburn/Wilmington town line, on the west by a Boston and Maine railroad spur and on the north by Eames Street. The location of the Facility is shown on Figure 1.1. The approximate UTM coordinates for the Facility (center of operating Facility area) are 4,710,566.177 northing and 323,074.140 easting. Figure 2.1 presents a copy of the 1992 aerial photograph for the Facility and surrounding area.

Approximately two thirds of the Facility is situated in an area designated as "Zone C" by the Federal Emergency Management Agency (FEMA) under the National Flood Insurance Program (NFIP). "Zone C" is outside both the 100-year and 500-year flood boundaries. The remaining one third of the Facility, the south-central portion of the Facility, is situated in an area designated as "Zone B" by the FEMA under the NFIP. "Zone B" is outside the 100-year flood boundary but within the 500-year flood boundary. Figure 2.2 presents the flood zones in the vicinity of the Facility, as determined by the FEMA.

The entire Facility is enclosed by an eight-foot high perimeter chain-link fence. The Facility is accessed from the north, off of Eames Street. Access to the Facility is restricted by locked gates when the Facility is unattended.

The Facility is immediately surrounded to the east, north and west by heavy and/or light industrial facilities and to its immediate south by the old Woburn Town Dump.

Further to the west of the Facility, along Main Street, Cook Avenue and Border Avenue, the land use primarily consists of single-family dwellings and some commercial and light industrial development.

Figure 2.3 presents a zoning map for Wilmington for the area immediately surrounding the Facility. As shown on Figure 2.3, the Facility and much of its surrounding area is zoned as General Industrial corresponding to the current land use.

2.2 SITE HISTORY

Information presented in this section has been supplied by Olin Corporation, and is based on Olin's own investigation of the Facility's history.

2.2.1 Ownership

The Facility, currently owned by Olin Corporation (Olin) was formerly owned by Stepan Chemical Company (1968-1980), National Polychemicals, Inc. (1953-1968), and American Biltrite Rubber (for a brief period in 1964). The Facility was closed by Olin in September 1986.

More specifically, from the Facility's construction in 1953 until 1968, it was owned by an entity known as National Polychemicals, Inc. (NPI). It is believed that NPI was initially operated by certain shareholders of American Biltrite Rubber (ABR) from about 1953, and that in 1959, NPI was transferred to American Biltrite Rubber (now known as American Biltrite, Inc.), which continued to operate NPI until 1964. (For approximately one month in early 1964, NPI was dissolved and the Facility was directly owned and operated by ABR.) From 1964 until 1966, NPI was operated by Fisons Limited (now Fisons plc). From 1966 until 1968, NPI was operated by Fisons

Corp., a subsidiary of Fisons Limited. Fisons Corp. merged in 1981 with FBC Chemicals, Inc., which is now known as NOR-AM Chemical Co.

Stepan Chemical Company (now known as Stepan Company) acquired NPI in 1968, and merged NPI into Stepan in 1971. Stepan continued to own and operate the Wilmington Facility until 1980, when it sold the Facility to Olin Corporation. Olin operated the Facility from 1980 until 1986.

2.2.2 Production Activities

The Facility historically manufactured chemical blowing agents, stabilizers, antioxidants and other specialty chemicals for the rubber and plastics industry. Table 2.1 presents a summary of Facility's historic processes, based on information currently available, including raw materials, wastes generated and corresponding years of production.

2.2.3 Waste Disposition

Prior to 1970, all liquid wastes generated at the Facility were discharged into a series of unlined pits in the central portion of the Facility or into the unlined Lake Poly located along the western boundary of the Facility. Figure 2.4, taken from a 1970 Wastewater Characterization Study report prepared for National Polychemicals, Inc., by Marine Research Laboratory, New London, Conn., identifies the former location of three pits and Lake Poly. Prior to 1964, with the construction of the two warehouses, two pits can be seen south of Plant C in early aerial photographs. These pits were located in the area of the two warehouses as shown on Figure 2.4. With the construction of the warehouses, in or about 1964, three new acid pits were constructed further south as shown on Figure 2.4.

A process sewer system collected concentrated acid wastes and dilute acid waste including weak acid streams, wash waters from products, filtrate, cooling tower blowdown, boiler blowdown and the pilot lab and discharged to the unlined pits.

It is believed that the unlined pits were associated with Facility production since the start of the Kempore process in 1956. From 1956 to 1967 sodium dichromate was used in the process and acidic waste containing chromium sulphate was believed to have been discharged to the pits and to Lake Poly. About 1967 the Kempore process was changed to use sodium chlorate and discharged acidic waste contained sodium chloride and sodium sulphate rather than chromium sulphate. Kempore was produced in Plant C, Plant C-2 and Plant C-3. The locations of these Plants and the sewer lines which discharged the acid wastes to the acid pits and Lake Poly are shown on Figure 2.4. It should be noted, however, that prior to 1964, two pits were located in the area of the two warehouses shown on Figure 2.4.

A second liquid disposal system collected yard drainage and process area floor drains. These areas collected truck unloading station or process area spills and discharged to the unlined Lake Poly. As mentioned above, it is believed that wastes from the Kempore process in Plant C were also discharged to Lake Poly as were wastes from the Opex process in Plant A which used 415 processing oil.

In 1970 Stepan completed a neutralization system including two lined lagoons. The acidic waste streams were neutralized with lime and the material sent to the lagoons. The supernatant was transferred to a clarifier and discharged "through its property" until the Metropolitan District Commission (MDC) sewer was completed in 1972, at which time it was discharged to the MDC sewer.

Calcium sulphate solids from the lined lagoons were dredged periodically and were landfilled on the southwest corner of the Facility (Sulphate Landfill). National Polychemicals received approval from the State for plans to construct the Sulphate Landfill in January 1974. Stepan received approval from the State to use the Sulphate Landfill in January 1975.

Subsequent to Olin's purchase of the Facility from Stepan in 1980, Lagoon I was relined in 1981 and Lagoon II was relined in 1983. After Olin discontinued operations at the Facility in 1986 both Lagoons I and II were drained, the water treated to remove sulphate and then discharged to the MDC sewer. The sludge and liners were excavated and taken and disposed of in the Sulphate Landfill.

Waste placement at the Sulphate Landfill ceased in December of 1986. Olin applied to the DEP in 1986 and 1987 to close the Sulphate Landfill and received agency approval on both submittals. Olin formally notified the DEP in 1988 that closure had been completed. The DEP then informed Olin that even though the DEP had previously approved the closure plans, closure of the Sulphate Landfill was not approved.

On March 19, 1992, Olin received a letter from the DEP requesting further documentation of the Sulphate Landfill. Olin met with the DEP and submitted previous information with which to support Olin's position that closure of the Sulphate Landfill was completed in accordance with the approved closure plan.

2.2.4 Historical Actions

The Plant B area has been an area of concern at the Facility. There have been various allegations, in interviews of former employees, of spills in the area, but no documentation of spills exists. Materials allegedly spilled include diisobutylene, diphenylamine, dioctylphthalate and dioctyldiphenylamine, and fuel oil.

When Olin purchased the Facility in 1980 from Stepan Chemical Company, the Plant B tank farm (SWMU No. 23) sat on grade with no perimeter dike or spill containment system. Olin subsequently installed a secondary containment system consisting of a concrete base slab and perimeter curbing.

In November of 1980, Olin entered into an Administrative Order with the DEP to stop the seep into the East Ditch. Olin installed four (4) pumping wells, between Plant B and the East Ditch, to provide hydraulic containment of the oil seep and extract contaminated groundwater from beneath Plant B. The extracted groundwater was treated and subsequently used in Facility operations as pump seal water.

In 1984, Olin installed five (5) new wells, closer to the East Ditch, to improve the capture of oil identified in the area.

After the Facility was closed in 1986, the extracted groundwater continued to be treated and was trucked to the Greater Lawrence Wastewater Authority POTW. Since October 1987, the treated groundwater has been discharged to surface, in the West Ditch, through a NPDES permitted outfall (SWMU No. 32).

In 1988, Olin installed three (3) large diameter (two 12-inch and one 16-inch) wells to replace the five (5) wells previously installed in 1984. The 1984 wells had begun to plug due to fouling of the screens with iron.

The current treatment system consists of overchlorination to remove ammonia, and granular activated carbon to remove organics.

2.3 PREVIOUS STUDIES

Several studies have been completed at the Facility in the past which document the Facility history since chemical manufacturing first commenced at the Site in 1953. The studies also document hydrogeologic and environmental investigations which have been conducted at the Facility since 1977.

A Massachusetts Field Investigation Team (FIT) Phase I Site Inspection Report prepared by Wehran Engineering Corp. in 1986 for the DEP presented a discussion of Facility location and description, Facility operational history, and results of past hydrogeologic and environmental investigations along with a Hazard Ranking System (HRS) Score for the Facility.

The Wehran FIT Report was based on Facility inspections conducted by Wehran and an extensive review of historical investigations including the following reports:

1. Hydrogeologic Investigation, February 1982, Malcolm Pirnie Inc.
2. Report on Groundwater and Surface Water Study, December 1978, Geotechnical Engineers Inc.
3. FIT Project - Site Inspection Report of Olin Chemicals Group Plant, December 1980, Ecology and Environment Inc.
4. Olin Chemicals Annual Groundwater Status Reports.

Further historic information is provided in annual monitoring program reports submitted to the DEP under an Administrative Order. These reports include:

1. Olin Chemical Site - Wide Hydrogeologic and Surface Water Study: 1986, dated December 5, 1986.
2. Groundwater and Surface Water Monitoring Status Report, Olin Corporation, Wilmington, Massachusetts, May 1987.
3. 1987 Site-Wide Status Report, Wilmington, Massachusetts, March 1988.
4. Olin - Wilmington, Massachusetts Facility Annual Groundwater Monitoring Report: 1988, dated January 19, 1989.
5. Olin - Wilmington, Massachusetts Facility Annual Groundwater Monitoring Report: 1989, dated May 1990.

6. Olin - Wilmington, Massachusetts Facility Annual Groundwater Monitoring Report: 1990, dated May 1991.

In addition to the annual monitoring program conducted by Olin, as documented in the above referenced reports, Olin has also undertaken the following activities/investigations during 1989 and 1990.

As part of the CSA Work Plan, a total of 34 Solid Waste Management Units (SWMUs), which are historic potential contaminant source areas, were identified by Olin at the Facility. Table 2.2 itemizes the SWMUs and Figure 2.5 locates the SWMUs.

In March 1989, Olin conducted a metal detection survey in an effort to identify potential areas of historic drum burial at the Facility. The results of the metal detection survey are presented Appendix C of the CSA Work Plan.

In May 1990, Olin collected sediment samples from the west and south ditches of the Facility for chemical analyses. The analytical results and sampling locations are presented in Appendix D of the CSA Work Plan.

In October 1990, Olin sampled nine private water supply wells to the west/southwest of the Facility. The samples were analyzed for the specified parameters and in accordance with the protocols required under Massachusetts Drinking Water Regulations 310 CRM 22.00. A copy of the analytical reports are provided in Appendix E of the CSA Work Plan. The type and location of the wells sampled and the analytical results are further discussed herein in Section 4.15.7.

In December 1991, as part of the CSA Phase II, CRA on behalf of Olin, prepared and submitted to the DEP the report entitled "Comprehensive Site Assessment Interim Report". This report documented

CSA activities and provided a hydrogeologic interpretation of conditions at the Facility based on established data at that time.

2.4 SITE UTILITIES

Based on information provided by Olin, historic and existing underground utilities are shown on Plan 1, enclosed and Figure 2.4. All historic underground utilities, identified on Plan 1 and Figure 2.4, which are no longer used by the Facility have been plugged by Olin. All surface and storm water catch basins have also been plugged. There is no point source stormwater discharge associated with the Facility. All stormwater flows off of the Facility in sheet flow run-off. The process sewer connections to the waste treatment plant have also been plugged. Therefore, the historic underground utilities at the Facility are not considered to represent a potential preferential route of migration of contaminants at the Facility. Also, the overburden at the Facility exhibits a hydraulic conductivity in the range of 10^{-1} cm/sec to 10^{-3} cm/sec (see Section 5.4). Any bedding material which may have been used when installing the underground utilities would probably exhibit hydraulic conductivities on the same order of magnitude. Therefore, the bedding material is not considered to represent a potential preferential route of migration of contaminants at the Facility.

3.0 REGIONAL SETTING

The following regional overview was derived principally from two sources: USGS Water Supply Paper 1694 "Geology and Groundwater Conditions in the Wilmington-Reading Area, Massachusetts" and "Aquifer Protection Study Town of Wilmington", prepared by IEP Inc. in 1990. For purposes of clarification, "Site" refers to the Facility grounds and surrounding region studied as part of the CSA, and "Facility" refers to that portion of the Site which lies within the Facility's property boundary.

3.1 REGIONAL TOPOGRAPHY

The Facility lies in the headwater regions of both the Aberjona River Basin and Ipswich River Basin. The surface water divide for these river basins is positioned just west and north of the Facility. The topography of the area is generally flat and low lying. Elevated areas are scattered across the area where bedrock ridges and knobs protrude from the relatively flat landscape. Surface elevations in the vicinity of the Site range from approximately 78 feet above mean seal level (AMSL) to approximately 82 feet AMSL in the flat low-lying areas to a maximum elevation of approximately 155 feet AMSL at the highest bedrock knob, which lies immediately west of the Facility. Plan 2, enclosed, presents a topographic map of the Facility and surrounding area.

3.2 REGIONAL GEOLOGY

In the area of the Site, unconsolidated glacial deposits overlying crystalline metamorphic and igneous bedrock constitute the two major geologic units. Figure 3.1 presents a generalized stratigraphic relationship between these units. The following subsections provide a discussion of the surficial and bedrock geology.

3.2.1 Surficial Geology

Regionally, the unconsolidated surficial deposits can be divided into three general units; glacial till, ice contact deposits, and outwash. Organic swamp deposits (peat) exist over much of the area. The parent bedrock of the glacially derived sediment is principally medium to coarse grained crystalline rock and as a result the glacial sediment is also relatively coarse grained. A general description of the three units including discussions of depositional origin, distribution and sedimentary characteristics is presented below.

Glacial Till

Glacial till is deposited directly by glacial ice typically at the base of the glacier (lodgement till) and or at the ice margin with little reworking by glacial meltwater (ablation till). In the area of the Site, both till types have been described (see Section 5.3). A lodgement till reportedly overlies bedrock in varying thicknesses up to ten feet thick. This till consists of poorly sorted mixtures of sand, gravel and boulders with a minor component of silt and clay. Lodgement tills are typically dense due to the compressive force of the glacial ice applied to the sediment during deposition.

Ablation till reportedly overlies much of the area, however, it is scattered and difficult to discern from other glacial sediment types. The ablation till consists primarily of sand through boulder sized material.

Ice Contact Deposits

Ice contact deposits are extensive throughout the area of the Site and are formed where high volumes of meltwater transport and deposit heavy loads of sediment at the immediate margin of the glacier. These deposits consist of poorly to moderately sorted, crudely stratified, mixtures of sand through boulder sized sediment. Ice contact deposits exist in thick packages and are the predominant unit filling some of bedrock valleys which exist in the area.

Glacial Outwash

As the glacial ice margin retreated further from the area of the Facility, glacial meltwaters transported and deposited an areally extensive outwash unit. This unit interfingers with and overlies the ice contact deposits in most areas. The outwash unit consists generally of stratified, moderately sorted fine to medium grained sand with minor interbeds of coarse sand and gravel. The outwash, though areally extensive, does not overlie the ice contact deposits in all areas.

3.2.2 Bedrock Geology

Throughout the area of the Site, the dominant bedrock type is dark gray, fine grained gneiss. The gneiss exhibits relict bedding and sedimentary structures and shows mineralogical and textural bedding that suggests a sedimentary rock protolith. A large ridge of this gneiss outcrops along the Woburn/Wilmington boundary as well as in scattered localities across the Site area. In general, the bedrock highs represent zones of greater erosional resistance.

Regional drilling and seismic data shows that the bedrock surface is dissected along zones of apparent weakness into "bedrock valleys". The valleys most likely existed prior to the last glaciation and were further eroded by glacial ice. Regionally, these valleys are associated with fault zones where the bedrock has been weakened by fracturing associated with movement along the faults.

3.3 REGIONAL HYDROGEOLOGY

3.3.1 Overburden Hydrogeology

The regionally extensive glacial fluvial deposits constitute important regional aquifers. Groundwater flow systems in the unconsolidated glacial sediments are closely integrated with the surface water drainage systems with recharge occurring in the upland areas of the basins and discharge occurring to the stream systems. Because the landscape is generally flat and the surface soils are composed primarily of sand and gravel, a high percentage of precipitation recharges the groundwater system.

Groundwater divides closely coincide with the surface water divides. As described in Section 3.4, the major river valleys and their tributaries overlay regional, buried bedrock valleys. The aquifers are thickest in these valleys and provide the principal groundwater resource for local municipalities (see Section 3.5). Hydraulic conductivity values in this aquifer range from 30 to 380 ft/day, (1.0×10^{-2} cm/sec to 1.3×10^{-1} cm/sec) in the ice contact deposits and 0.04 to 114 ft/day (1.4×10^{-5} cm/sec to 4.0×10^{-2} cm/sec) in the outwash (IEP, 1990 p.19).

3.3.2 Bedrock Hydrogeology

The bedrock in the area of the Site is moderately to weakly fractured with a zone of higher degree of fracturing found at the top of the bedrock surface. Fracturing diminishes, in general, within five to ten feet of the bedrock surface. Correspondingly, little groundwater is transmitted through the bedrock below the upper fractured surface. Wells completed regionally in the bedrock are typically constructed with several hundred feet of open hole and produce yields adequate for only domestic use. The typical bedrock well yields 0.5 to 60 gpm (USGS-1694, p.17).

3.4 REGIONAL SURFACE WATER HYDROLOGY

The Site lies in both the headwaters of the Ipswich River and the Aberjona River watersheds. The surface water divide separating these two watersheds runs just west and north of the Facility. The principal tributaries which drain the Site and feed these rivers are:

- Maple Meadow Brook which lies west of the Facility and flows north to the Ipswich River; and
- A network of drainage ditches which drain the Facility and flow south to Halls Brook which in turn flows into the Aberjona River.

Figure 3.2 identifies the two drainage basins.

The principal streams which drain the Site, and to some extent their tributaries, are located over buried bedrock valleys which dissect the region. Both the Ipswich and Aberjona Rivers overlie well defined bedrock valleys.

The streams in the area derive their principal component of flow from groundwater discharge. Stream flows fluctuate in response to seasonal changes in evapotranspiration rates, and to some extent precipitation events.

3.5 WATER RESOURCES

Located approximately 4,000 feet northwest of the Facility are three Town of Wilmington well fields at Chestnut Street, Butters Row and Town Park The locations of these wells are shown on Plan 3, enclosed and on Figure 3.3.

The wells are completed in a thick sequence of sand and gravel which fills a bedrock valley associated with Maple Meadow Brook, a tributary of the Ipswich River. A summary of the Town of Wilmington production wells located west of the Facility is presented in Table 3.1. Construction details for these wells were obtained from Town of Wilmington and are presented in Appendix A.

As shown in Table 3.1, the combined maximum design yield of these wells is 4.6 million gallons per day (MGD) which comprises approximately 49.5 percent of the Town of Wilmington's maximum design yield. However, the average production rate for these wells is approximately 2.3 MGD which comprises approximately 62.2 percent of the Town of Wilmington's average production rate. The discharge from Butters Row, Chestnut Street and Town Park are combined at the Butters Row Treatment Plant for treatment prior to distribution.

The groundwater is initially treated by conventional aeration. Alum, potassium permanganate, and polymer are added to aid in the removal of the particulate matter, followed by granular activated carbon units to remove the remaining organics. The pH is then adjusted with the addition of lime and chlorine gas is bubbled through the water for disinfection purposes.

The Town of Wilmington wells located west of the Facility were sampled by CRA and Coast-to-Coast Analytical Services, Inc. (formerly ABB) personnel during the CSA activities, as discussed in Section 4.15.8.

The sand and gravel aquifer, and to some extent the bedrock, also provide water to private wells located west of the Facility.

Altron Corporation (Altron) located approximately 500 feet west of the Facility currently has two wells in operation which are pumped at approximately 136,000 gpd (communication with Altron 1993). The groundwater is used as non-contact cooling water and a portion is treated for use in its process. The water is then discharged to the Massachusetts

Water Resource Authority sewer system. Available well logs and chemical data from the Altron property are located in Appendix A. It should be noted that a well was constructed at Altron in 1977 in which, upon well development, "green" water was pumped from a depth of approximately 67 feet below ground surface. The "green" water is characteristic of the groundwater plume migrating from the Facility (see Section 6.0). This is noted on a well log located in Appendix A. The location of Altron relative to the Facility is shown on Plan 3, enclosed and on Figure 3.3.

Private well inventories conducted by Olin and CRA over the course of the CSA, identified residences west and southwest of the Facility who have private wells. Table 3.2 summarizes by plot and parcel number, private residences west of the Facility, along Main Street and Cook Avenue and southwest of the Facility along Border Avenue and indicates which residences are connected to town water and which residences have private wells. Figure 3.3 identifies the location of the private residences by plot and parcel number. All of the identified private wells in the vicinity of the Facility were sampled by Olin during CSA activities, as discussed in Section 4.15.7.

The aquifer which occupies the Aberjona River Basin is also considered a primary source of groundwater for the Woburn, Massachusetts region. Currently, however, wells located in the northern portion of the Town of Woburn are not being pumped. Also, in the vicinity of the Site, no private wells were identified to exist in the northern portion of the Town of Woburn.

3.6 CLIMATE

The climate in this region is humid and temperate with fairly uniform monthly precipitation. The average annual precipitation recorded at Reading, Massachusetts is 40.9 inches with October typically being the driest month and April being the wettest. Seventy-five percent of the precipitation occurs during the frost free season. The mean January temperature is 26.6°F and the mean July temperature is 73.7°F with a mean annual temperature of 49.8°F. The prevailing wind direction is from the west northwest during the winter months, and from the southwest during the summer months with an average windspeed of 7 knots (Hanscom Field Airport, Bedford, Ma).

4.0 CSA PHASE II FIELD ACTIVITIES

As discussed in Section 1.0, the objective of the CSA is to conduct a systematic investigation and assessment of the Facility to characterize the type and quantity of oil or hazardous materials released at or from the Facility in order to characterize and evaluate the risk or harm, if any, that the Facility poses to health, safety, public welfare and the environment. This section summarizes the investigation activities.

4.1 CSA FIELD ACTIVITIES SUMMARY

The following field activities were implemented/completed during the CSA to collect the necessary data to complete the objectives of the CSA:

1. Aerial fly-over and surveying for topographic map;
2. Implementation of a magnetometer survey/test pit program to identify any potential buried drums at the Facility;
3. Implementation of a soil gas survey/test pit program to identify any potential buried drums beneath the warehouses at the Facility;
4. Completion of seismic refraction survey to aide in the determination of bedrock topography;
5. Installation of new monitoring wells both on and off the Facility;
6. Development and permeability testing of new monitoring wells;
7. Collection of potentiometric groundwater elevations to determine groundwater flow rate and direction;
8. Downhole electromagnetic (EM) logging and temperature logging to help delineate the groundwater contaminant plume;
9. Installation of surface water piezometers and staff gauges to monitor surface water flow;
10. Completion of a qualitative biota/wetlands delineation survey;
11. Collection of excavated drum samples for chemical analyses;

12. Installation of investigative soil borings and collection of subsurface soil samples for chemical analyses;
13. Collection of surface soil samples for chemical analyses;
14. Collection of groundwater samples for chemical analyses from existing monitoring wells, new monitoring wells, residential and town wells; and
15. Collection of surface water and sediment samples for chemical analyses from surface ditches.

The above list of activities includes both those activities identified in the CSA Work Plan and additional activities not identified in the CSA Work Plan. The additional activities consist of above activities 3, 4, 8 and 9. The additional activities also included the completed of additional boreholes and monitoring wells and additional soil, groundwater, sediment and surface water sampling beyond that indicated in the CSA Work Plan.

A summary of CSA field activities including commencement and completion dates is presented in Table 4.1. The following subsections present detailed discussions of the CSA activities. All CSA activities, unless otherwise noted, were conducted in accordance with the protocols/procedures presented the CSA Work Plan.

4.2 TOPOGRAPHIC MAP

A topographic map of the Site was prepared by Dana F. Perkins, Inc., Consulting Engineers & Land Surveyors of Reading, Massachusetts as part of the CSA. The topographic map was prepared using aerial photography combined with ground control survey, as required. The topographic map was prepared in two stages. An initial topographic survey of the Facility was conducted in December 1990 and encompassed an area of approximately 130 acres. In December 1991, the topographic survey was expanded beyond the area of the Facility to include an additional 445 acres. In total, the topographic map prepared covers an area of approximately 575 acres.

Plan 2, enclosed, presents the topographic map. The topographic map is drawn at a scale 1"=200' and presents ground surface contours at 1-foot intervals. Vertical control is referenced to mean sea level (MSL) and horizontal control is referenced to USGS datum.

4.3 FACILITY MAGNETOMETER SURVEY

From December 14, 1990 through January 8, 1991, LGI, a division of Layne GeoSciences Inc., performed an extensive magnetometer survey of the Facility to determine the potential presence and location of buried drums. A copy of LGI's Geophysical Investigation Report is provided in Appendix B and Plan 4, enclosed, presents a magnetic gradient map interpretation based on the survey.

The geophysical investigation identified a total of 12 anomalies of unknown or suspicious manner which could be potentially associated with buried drums or tanks. The anomalous areas are identified in the Geophysical Investigation Report (Appendix B) and also on Plan 5, enclosed.

4.4 FACILITY FIELD TEST PIT EXCAVATIONS

4.4.1 General

Based on the results of the magnetometer survey (see Section 4.3), it was determined that a series of test pit excavations would be completed to investigate the anomalies of unknown or suspicious manner. Prior to commencing test pit excavations, a report entitled "Work Plan, Test Pit Excavation Program, Wilmington Facility, Wilmington, Massachusetts, Olin Corporation, August 14, 1991" (Facility Test Pit Work Plan), was prepared by CRA and reviewed and approved by Olin. The Facility Test Pit Work Plan included a materials handling plan, sampling protocols, analytical protocols and a health and safety plan. The Facility Test Pit Work Plan was adhered to during all test pit excavation activities. From October 2, 1991 through October 10, 1991, Clean Harbors of Kingston, Inc. (Clean Harbors) performed the test pit excavation program under the supervision of Olin and CRA personnel.

4.4.2 Field Activities

Clean Harbors performed the test pit excavations using a large excavator, a medium sized backhoe, and a small "bobcat" backhoe. The excavator was used in areas of easy access, the backhoe was used where access was restricted by dense vegetation, and the "bobcat" was used in areas where soft wet soil conditions existed. Clean Harbors provided a crew of four people: an excavator operator; two field technicians; and a site supervisor/health and safety officer.

The test pits were advanced by removing approximately two to six inches of soil from the excavation until buried wastes and/or groundwater was encountered. If drums and/or buried wastes were encountered, the excavation was extended in a lateral direction to define the horizontal extent of buried drums and/or wastes.

Twenty-eight test pits were excavated within the 12 anomalous areas identified by the magnetometer survey. One additional test pit was also excavated in an area identified by a former Facility employee as a potential area of drum disposal. Therefore, a total of 29 test pits were excavated at the Facility. Plan 5, enclosed, locates the test pit locations.

In areas where buried drums or visibly contaminated soils were identified, samples were collected for chemical analysis. A total of eight drum and/or soil samples were collected for chemical analysis as summarized in Table 4.2. A representative cross-section of encountered wastes was sampled for chemical analyses in order to provide as complete an inventory as possible of buried wastes. The presence/characterization of buried drums/waste is discussed in detail in Section 5.6.

Five drums were excavated during sampling and were placed into DOT-approved 85-gallon overpack drums. The drums were moved to a staging area at the Facility, subsequently characterized by Olin and were disposed of off Site, at a facility meeting Federal and State regulations.

4.5 WAREHOUSE SOIL GAS SURVEY

From February 5, 1992 through February 7, 1992, LGI performed a soil gas survey beneath the floor of two warehouse buildings at the Facility. The soil gas survey was conducted in an attempt to delineate areas under the warehouses which may be indicative of buried waste. Early aerial photographs of the Facility show two (2) pits behind Plant C with drums clearly present. A later aerial photograph shows the two large warehouses built over the location where the pits had previously been. Interviews by Olin, with previous employees indicated that drums may have been buried under the warehouses during construction. The soil gas survey identified three areas which could potentially be indicative of buried wastes. A copy of LGI's Soil Gas Survey Report is provided in Appendix C.

4.6 WAREHOUSE TEST PIT EXCAVATIONS

4.6.1 General

Based on the results of the soil gas survey (see Section 4.5), it was determined that a series of test pit excavations would be completed in the area of the warehouses to investigate the potential of buried wastes. Prior to commencing the test pit excavations, a report entitled "Work Plan, Test Pit Excavation Program, Warehouse Buildings, Wilmington Facility, Wilmington, Massachusetts, Olin Corporation, July 1992" (Warehouse Test

Pit Work Plan) was prepared by CRA and reviewed and approved by Olin. The Warehouse Test Pit Work Plan included a materials handling plan, sampling protocols, analytical protocols and a health and safety plan. The Warehouse Test Pit Work Plan was adhered to during all test pit excavation activities. From July 27, 1992 through July 30, 1992, Clean Harbors performed the test pit excavation program under the supervision of CRA personnel.

4.6.2 Field Activities

Clean Harbors performed the test pit excavations using a medium sized backhoe and a "bobcat" loader equipped with a concrete breaker. Clean Harbors provided a crew of four people: a site supervisor; an excavator operator; one field technician/chemist; and a health and safety officer.

At each test pit location, the concrete floor was initially sawcut and then broken up using the "bobcat" loader equipped with a concrete breaker. The concrete pieces were removed using the backhoe and stockpiled at the Facility. The test pits were advanced by removing approximately six to 12 inches of soil from the excavation until groundwater was encountered. All excavated soil was placed on polyethylene sheets immediately adjacent to the excavation. Soil samples were collected from the base of each test pit excavation for headspace screening using an HNu meter. Table 4.3 provides a summary of the HNu meter readings at each test pit location. Based on visual inspection and the HNu screening, no samples exhibited evidence of contamination, therefore, no samples were collected for chemical analysis. Upon confirmation of the absence of drums/drum wastes in the test pits, each test pit excavation was backfilled with the previously excavated material.

A total of nine test pits were excavated within the three anomalous areas identified by the soil gas survey. Figure 4.1 locates the warehouse test pit excavations.

4.7 SEISMIC REFRACTION SURVEYS

LGI was also retained to perform seismic refraction surveys at the Site to aid in the determination of the underlying bedrock topography for the selection of monitoring well locations outside of the Facility's boundary. LGI conducted two separate seismic refraction surveys; one in October 1991 and one in February 1992.

A discussion of the methods and results of the two seismic investigations are presented in the reports entitled "Geophysical Investigation, Olin Chemical Facility, Wilmington, Massachusetts, November 1991" and "Geophysical Investigation, Olin Chemical Facility, Wilmington, Massachusetts, March 1992" presented in Appendix D. Plan 6, enclosed, shows the locations of the seismic refraction survey lines.

4.8 MONITORING WELL INSTALLATIONS

Monitoring wells were installed on and in the vicinity of the Facility throughout the period of June 1991 to May 1993. All monitoring well installations were completed by Soil Exploration of Leominister, Massachusetts under the supervision of CRA personnel. Prior to drilling at any location, the appropriate Wetlands Commission approvals were obtained by Olin.

A total of 70 groundwater monitoring wells (GW-4D and well nests GW-40 through GW-75) were installed at the Site: 31 monitoring the upper portion of the unconsolidated aquifer (including well GW-62M); 35 monitoring the lower portion of the unconsolidated aquifer and upper fractured portion of the bedrock; and 4 wells monitoring only the upper fractured portion of the bedrock encountered beneath the Site surrounding area.

Plan 3, enclosed, shows the location of all existing monitoring wells and all monitoring wells installed as part of the CSA activities. As part of the CSA activities all existing Facility monitoring wells were inventoried and assessed. Olin secured all existing monitoring wells with lockable caps not already secured and performed any surface repairs required. Table 4.4 provides a summary of all monitoring well construction details. Stratigraphic and instrumentation logs for all wells are provided in Appendix E.

Shallow overburden wells were installed using hollow stem augers (4 1/4-inch inside diameter, nominal 8-inch outside diameter). Each shallow well was constructed of 10-foot long, 2-inch diameter PVC screen and PVC pipe riser. The top of the screen was set approximately one foot above the static water level determined during drilling.

Deep wells were installed to monitor the upper fractured portion of the bedrock and the immediately overlying strata. Temporary 5-inch diameter casing was advanced to the top of bedrock. A corehole was then advanced approximately five feet into the bedrock using wet rotary techniques and continuous sampling with NX size equipment. The core was inspected to determine the depth to the most fractured zone in the 5-foot core. Subsequently, the corehole was reamed out to the base of the most fractured zone using a 5 7/8-inch diameter Tricone drill bit. Each deep well was then constructed of 10-foot long, 2-inch diameter, PVC screen and PVC pipe riser.

Bedrock wells were installed to monitor the fractured portion of the bedrock. Bedrock wells were installed by advancing a nominal 5-inch diameter casing to the top of bedrock. After the 5-inch diameter casing had been set to bedrock, the bedrock was cored using HQ sized coring equipment. The core was logged by the on-Site geologist noting lithology, and pertinent structural geologic features (i.e. fracture and joint style, frequency, and orientation). At a depth where fracturing had diminished, the hole was reamed to a diameter of 4 7/8 inches. Flush threaded 4-inch diameter PVC casing was then installed and grouted into the reamed bedrock corehole. The casing was allowed to set a minimum of 48 hours to ensure that an adequate seal had achieved.

The well was then further advanced by coring using HQ sized coring equipment. The corehole functions as the monitored zone for the well. The on-Site geologist determined the final depth of the corehole based on the interpretation of the drill core.

At completion, all monitoring wells were secured with lockable caps and locks.

Following installation, all monitoring wells were developed prior to sampling in accordance with the protocols presented in Appendix H of the CSA Work Plan.

All development water from wells located on the Facility was discharged to the ground surface away from the well. All development water from wells located off the Facility was collected in 55-gallon drums and transferred to a tank at the Facility. The development water in the tank was sampled and characterized by Olin and disposed of off Site at a facility meeting State and Federal regulations.

All remaining soil cuttings from well installations were collected, placed into DOT-approved 55-gallon drums and transferred to a staging area at the Facility. The drummed soils were sampled and characterized by Olin and disposed of off Site at a facility meeting State and Federal regulations.

4.9 HYDRAULIC CONDUCTIVITY TESTING

Selected overburden monitoring wells were tested for in situ hydraulic conductivity of the screened portion of the aquifer. The tests were conducted by using two methods.

The first method termed a slug test was performed by quickly inserting a PVC rod or "slug" of known volume into the water column within the monitoring well which resulted in a sudden rise of the water in the well in response to the increase of volume. The change in water level over time was recorded using a pressure transducer connected to a data logger. This is termed a "falling head" test. After the well was stabilized, the slug was then quickly removed from the well resulting in a sudden lowering of the water table. The recovery of the water table is then recorded with the data logger. This is termed a "rising head" test.

Because wells responded very quickly to the slug tests (i.e. hydraulic conductivities were too great to collect adequately spaced data), single well pumping tests were then conducted on selected overburden monitoring wells. This test was conducted by pumping the monitoring well using a Grundfos 2.0-inch submersible pump to purge the monitoring well while simultaneously recording the water level response (drawdown) with a pressure transducer connected to a data logger. A maximum pumping rate of seven gallons per minute was achieved with the Grundfos pump. After the well reached stabilization (i.e. drawdown had ceased), the pump was shut off and the resulting recovery was recorded with the data logger.

During the single well pumping tests in the overburden wells, the water levels exhibited very little measurable drawdown when pumped at seven gallons per minute. The wells reached stability soon after pumping commenced indicating high hydraulic conductivities of the screened portion of the aquifer.

Single well pumping tests were also conducted in selected bedrock wells using the same procedure as discussed above for the overburden monitoring wells. These tests generated drawdown and recovery data which indicated very low hydraulic conductivities for the bedrock formation.

The slug test and pumping test data and data interpretation are presented in Appendix F. Table 4.5 summarizes the resulting hydraulic conductivities calculated or estimated.

As summarized in Table 4.5, the horizontal hydraulic conductivity for the monitored intervals of the glacial fluvial deposits (overburden) ranged from 7.7×10^{-2} cm/sec to 9.7×10^{-4} cm/sec, with a geometric mean of 7.9×10^{-3} cm/sec. These data are consistent with the regional hydraulic conductivity data discussed in Section 3.3.

As also summarized in Table 4.5, the horizontal hydraulic conductivity for the monitored intervals of the bedrock ranged from 1.20×10^{-5} cm/sec to 2.26×10^{-5} cm/sec, with a geometric mean of 1.715×10^{-5} cm/sec. These data are consistent with the regional groundwater availability in the bedrock as discussed in Section 3.3.

4.10 SURFACE WATER PIEZOMETER AND STAFF GAUGE INSTALLATIONS

A total of ten piezometers and two staff gauges were installed in the West Ditch network and Maple Meadow Brook, respectively, for the purpose of obtaining surface water and groundwater elevation data.

The piezometers installed in the West Ditch network, consist of a 2-foot length of stainless steel "wire wound" well screen coupled and threaded to a 2-inch steel pipe riser. The piezometers were driven by hand into the ditch bottom a minimum of 1/2 foot beyond the top of the screen. The piezometers were installed in July 1992 by Soils Exploration under the supervision of CRA personnel. The piezometers were installed to assist in the design of an interim action plan to control a white "floc" material surfacing in the drainage ditch west of the Facility. A report entitled "Interim Action Plan, West Ditch Precipitate, Olin Corporation, Wilmington Facility, Wilmington, Massachusetts" dated September 1992, prepared by CRA, was submitted to the DEP in September 1992.

The staff gauges installed in Maple Meadow Brook consist of 4-foot long fence posts. The posts were driven by hand into the stream bottom a minimum of two feet. The staff gauges were installed by CRA personnel in October 1992. The staff gauges were installed to provide additional information to confirm that the wetlands in the area of Maple Meadow Brook is a recharge area. The location of the piezometers and staff gauges are presented on Plan 3, enclosed.

4.11 WATER LEVEL MONITORING

Following completion and development of all new monitoring wells, all existing and new wells, piezometers and staff gauges were surveyed for horizontal and vertical control by Dana F. Perkins. Water levels in the monitoring wells have been measured seven times between September 30, 1991 and April 21, 1993. Table 4.6 summarizes groundwater elevations measured over this period. Water levels in the surface water piezometers have been measured four times, July 22, 1992, September 3, 1992, January 7, 1993 and April 21, 1993. Table 4.7 summarizes the surface water piezometer elevations. Water levels at the staff gauges installed in Maple Meadow Brook were measured on April 21, 1993 and are summarized in Table 4.7.

4.12 DOWNHOLE ELECTROMAGNETIC LOGGING

Following well installation and development, a downhole geophysical electrical conductivity (EM) survey was conducted on selected wells to aid in defining the vertical extent of contaminants in the aquifer.

The EM survey was conducted by lowering a probe with a transmitter coil and receiver into the well. The transmitter, mounted at the top of the probe, induced an electric current into the geologic formation. This current produced a secondary electromagnetic field within the formation. The receiver, mounted at the bottom of the probe, measured the strength of the electromagnetic field induced by the transmitter coil. The strength of the electromagnetic field as recorded at the receiver is directly proportional to the ability of the geologic formation to "conduct" electricity. If contaminants were present dissolved in the groundwater, a corresponding elevated conductivity anomaly would be noted during EM logging.

Hager-Richter Geoscience Inc. of Salem, New Hampshire conducted the downhole EM logging in both August of 1992 and December 1992/January 1993. A discussion of the methods and results of the downhole EM logging is presented in Appendix G. The EM logging results *are also discussed in Section 6.0.*

4.13 TEMPERATURE LOGGING

Hager-Richter Geoscience Inc. also conducted dual temperature logging in the newly installed bedrock monitoring wells. Temperature logging was used to help identify potential water bearing fractures which may exist in the bedrock wells. A discussion of methods and results of the temperature logging are presented in Appendix G. The *temperature logging results are also discussed in Section 5.4.*

4.14 QUALITATIVE BIOTA SURVEY/WETLANDS DELINEATION

Olin retained the firm Wetlands Preservation, Inc., of Georgetown, Massachusetts to conduct a detailed evaluation of the location and characteristics of the various upland and wetland habitat areas on and immediately adjacent to the Facility. The evaluation is documented in the report entitled "Site Habitat Characterization, Olin Chemical Facility, 51 Eames Street, Wilmington, Massachusetts" dated March 1993 and is presented as Appendix H. The report presents an upland habitat and wetland habitat evaluation and wildlife utilization.

4.15 CSA CHEMICAL SAMPLE COLLECTION

4.15.1 Groundwater Sampling

An initial set of groundwater samples was collected from all existing and new groundwater (GW) and sulphate landfill (SL) monitoring wells. The wells were sampled in August of 1991 by ABB personnel and were analyzed for groundwater indicator parameters ammonia, chromium, sulphate and chloride . Subsequent to this, between the period of January 1992 and May 1992, as each new well nest was completed, the wells were developed and initially sampled by CRA personnel for groundwater indicator parameter analysis. Table 4.8 summarizes when each well was sampled for the indicator parameter analysis. Subsequent to May 1992, all new wells were sampled as part of the Site Specific Parameter List (SSPL) groundwater sampling events which included indicator parameter analysis.

In December 1991, a set of groundwater samples were collected by CRA personnel from eleven selected monitoring well locations. The wells were selected based on historic and inorganic analytical data and observations made during drilling of new wells. These wells were sampled and analyzed for the full list of Target Compound List/Target Analyte List

(TCL/TAL) compounds plus 2,4,4-trimethyl-1-pentene, 2,4,4-trimethyl-2-pentene, ammonia, chloride and sulphate. Table 4.9 summarizes the eleven wells sampled in December 1991.

Based on a review of the data from the eleven wells sampled in December 1991, a Site Specific Parameter List (SSPL) was developed for future groundwater, surface water and sediment sampling and analysis. The SSPL included the above parameter list except for PCBs.

Subsequent to the development of the SSPL, two rounds of groundwater samples were collected from all new monitoring wells and selected existing monitoring wells. Prior to sample collection, all monitoring wells were first purged in accordance with the protocols in Appendix H of the CSA Work Plan. All samples were analyzed for the SSPL compounds and selected samples were also analyzed for hexavalent chromium and specific gravity. The two rounds of samples were collected in August of 1992 and October/November of 1992. Wells installed after the October/November 1992 sampling event were sampled after development and are considered part of the second round sampling event. Tables 4.10 and 4.11 summarize the wells sampled during each round, respectively. Plan 3, enclosed, presents all monitoring well locations.

A peristaltic pump was used for the collection of all samples except the volatile parameter group. Volatiles were collected using a bottom filling stainless steel/teflon bailer attached to new nylon rope. Prior to use in any monitoring well, the sampling program equipment was precleaned as described in Appendix H of the CSA Work Plan. New nylon rope and dedicated teflon tubing were used at each well location.

In the event that the groundwater was still turbid following purging, appropriate sampling techniques (i.e. low pumping rate) were implemented to collect sediment-free samples or samples that were as sediment-free as possible. In the event that a well was purged dry, sample collection commenced on the day of purging when the water level recovered to the static water level.

Filtration of water samples (0.45-micron filter, millipore aseptic unit or equivalent) in which analyses for TAL parameters was to be performed was undertaken for all monitoring well samples prior to preservation.

4.15.2 Surface Water Sampling

Two rounds of surface water samples were initially collected by CRA personnel from locations along the surface drainage ditches. These locations provided samples from upstream, adjacent, on and downstream of the Facility from the West, South and East Ditches. Surface water samples were collected and analyzed for the same parameters as the groundwater samples (SSPL compounds). Selected samples were also analyzed for hexavalent chromium. Round 1 surface water samples were collected in August/September 1992 and Round 2 surface water samples were collected in December 1992, subsequent to completing each groundwater sampling event. After review of both rounds of surface data, water samples were collected in the East Ditch further upstream and downstream of the Facility. These samples were collected in March/April 1993, and are considered part of the Second Round Sampling event. Tables 4.12 and 4.13 summarize the surface water samples collected during each round, respectively. Plan 7, enclosed, shows all surface water sample locations.

Surface water samples were collected in accordance with the protocols presented in Appendix H of the CSA Work Plan.

4.15.3 Sediment Sampling

Similar to surface water sampling, two rounds of sediment samples were initially collected by CRA personnel from locations along the surface drainage ditches. These locations provided samples from upstream, adjacent, on and downstream of the Facility from the West, South and East Ditches. Sediment samples were collected concurrent with surface water samples. Tables 4.14 and 4.15 summarize the sediment samples collected during each round, respectively. Plan 7, enclosed, shows all sediment sample locations.

A stainless steel spoon was used to reach the base of the ditch sediments. A composite sample was collected from each distinct layer of sediment encountered at each sampling location and analyzed for the same parameters as the groundwater samples (SSPL compounds). Selected samples were also analyzed for hexavalent chromium.

Sediment sampling was conducted according to the protocols presented in *Appendix H of the CSA Work Plan.*

4.15.4 Subsurface Soil Sampling

4.15.4.1 Subsurface Soil Sampling - Physical Characteristics

During borehole drilling for the new monitoring wells, continuous split spoon overburden samples were collected to the completed depth. Where a shallow well was installed in association with a deep well, split spoon sampling was only undertaken at the deep well location. All soil samples were described and classified according to the Unified Soil Classification System (USCS). All soil samples were retained for geologic record and are currently stored at the Facility.

4.15.4.2 Subsurface Soil Sampling - Chemical Characteristics

In order to characterize the soils of known and potential source areas (i.e. SWMUs), a total of 40 investigative boreholes were completed at the Facility, by Soil Exploration, under the supervision of CRA personnel, in June 1991 and February 1992.

The boreholes were completed to the top of the water table using hollow-stem augers (4 1/4-inch inside diameter, nominal 8-inch outside diameter). After completion each borehole was backfilled to ground surface with cement/bentonite grout.

In 36 of the boreholes, continuous split spoon soil samples were collected during augering from ground surface to the top of the water table (approximately 10 feet deep). A minimum of one discrete soil sample for chemical analyses was selected from each borehole location. Samples were selected based on field screening with an HNu immediately upon opening of the split spoon, visible evidence of contamination, and grain size of recovered materials. One soil sample from each borehole was analyzed by the laboratory for the full list of TCL/TAL compounds plus 2,4,4-trimethyl-1-pentene, 2,4,4-trimethyl-2-pentene, ammonia, chloride and sulphate.

Three boreholes in the former black area east of Plant D (BH23, BH24, BH25) and one borehole in the area of the former Wytox Loading Area spill (BH11) were completed to obtain samples for analysis of the two areas. Historically, both areas were excavated and backfilled with clean fill. Continuous split spoon soil samples for geologic record were collected from ground surface to the base of the clean fill. Immediately below the clean fill soil samples for chemical analyses were collected. The soil samples from each of the boreholes were analyzed by the laboratory for the full list of TCL/TAL compounds plus 2,4,4-trimethyl-1-pentene, 2,4,4-trimethyl-2-pentene, ammonia, chloride and sulphate.

One background subsurface soil sample was collected during the installation of monitoring well GW-67D, located approximately 1,400 feet west of the Facility.

Table 4.16 summarizes the subsurface soil samples collected for analysis. Plan 8, enclosed, shows the location of all the investigative soil borings completed as part of the CSA activities. Stratigraphic logs for the boreholes are provided in Appendix I.

All remaining soil cuttings at borehole locations were collected, placed in 55-gallon drums and transferred to a drum staging area at the Facility. Subsequent to receiving the subsurface soil analyses, the drummed soils were characterized by Olin and disposed of off Site at a facility meeting State and Federal regulations.

4.15.5 Surface Soil Sampling

A surface soil sampling program was conducted by CRA personnel in July 1991, over the area of the Facility on an approximate 200-foot grid. In addition, four composite surface soil samples were collected from areas of suspected surficial contamination, one composite surface soil sample was collected for chromium speciation and one background surface soil sample was collected during the installation of monitoring well GW-67D. Soil samples were collected at all locations from zero to six inches below the ground surface. All samples were collected in accordance with the protocols presented in Appendix H of the CSA Work Plan. Table 4.17 summarizes the surface soil samples collected and Figure 4.2 shows the locations of all surface soil sample locations.

As shown on Figure 4.2, the Facility was divided into ten areas for the purpose of compositing grid samples. Samples collected from within each area were composited in the laboratory and analyzed for the full

TCL/TAL parameters plus 2,4,4-trimethyl-1-pentene, 2,4,4-trimethyl-2-pentene, ammonia, chloride and sulphate.

Three hand-auger soil samples were collected from the soil at the base of the black oily area on the south ditch bank (SWMU No. 30). The samples were composited in the laboratory and analyzed for the above list of parameters.

Three hand-auger soil samples were collected from the black area near the West Ditch (SWMU No. 27). The samples were composited in the laboratory and analyzed for the above list of parameters.

Three hand-auger samples were also collected from the area near monitoring well nest GW-55. This area were not identified in the CSA Work Plan however, at time of sampling, it exhibited signs of stressed vegetation. The samples (designated as SWMU No. 33) were composited in the laboratory and analyzed for the above list of parameters.

Four surface soil samples were also collected from the fuel oil spill area (SWMU No. 25). The samples were composited in the field and analyzed for the above list of parameters.

One background surface soil sample was collected during the installation of monitoring well GW-67D, located approximately 1,400 feet west of the Facility. The background sample was analyzed for TCL Polynuclear Aromatic Hydrocarbons (PAHs) and TAL parameters.

4.15.6 Air Sampling

As discussed in Section 5.2, the Facility is completely covered by either building, asphalt or good vegetative cover in all areas. Thus, the potential for particulate emissions at the Facility is extremely low. As discussed in Section 6.3, no volatile organic compounds (VOCs) were detected in the surface soil samples and only low levels of VOCs were detected in subsurface soil samples. Thus, the potential for vapor emissions at the Facility is extremely low. Therefore, based on existing Facility conditions and on the analytical results for the surface and subsurface soil samples, air sampling and analysis was determined not to be required.

4.15.7 Private Well Sampling

4.15.7.1 Cook Avenue/Border Avenue Wells

In October 1990, ABB personnel, on behalf of Olin, sampled a total of nine private wells at residences located along Cook Avenue and Border Avenue, to the west southwest of the Facility. The wells were sampled in order to confirm that the wells had not been impacted by any Facility-related contaminants. The nine wells sampled are summarized in Table 3.2 and are located on Figure 3.3. All wells, with the exception of one well on Border Avenue, are completed in the bedrock.

The samples were collected by ABB in accordance with the protocols presented in Appendix E of the CSA Work Plan.

All samples were analyzed for the specified parameters and in accordance with the protocols required under Massachusetts Drinking Water Regulations 310 CRM 22.00. A copy of analytical reports are provided in Appendix E of the CSA Work Plan.

A review of the analytical reports presented in Appendix E of the CSA Work Plan indicates that the private well water samples from the Cook and Border Avenue residences were below all acceptable Massachusetts Drinking Water Regulations and were not impacted by any Facility-related contaminants. A summary of parameters included in the Massachusetts Drinking Water Regulations is provided in Appendix E of the CSA Work Plan.

4.15.7.2 Main Street Wells

In September 1991, Olin sampled a total of five private wells at residences located to the west of the Facility along Main Street. The wells were sampled in order to determine if the wells had been impacted by any Facility-related contaminants. The five wells sampled are summarized in Table 3.2 and are located on Figure 3.3. As shown in Table 3.2, the five wells are all completed in the shallow overburden.

The samples were collected by Olin in accordance with the protocols presented in Appendix J.

All samples were analyzed for the specified parameters and in accordance with the protocols required under Massachusetts Drinking Water Regulations 310 CRM 22.00. A copy of the analytical reports are provided in Appendix J.

A review of the analytical reports presented in Appendix J indicates that the private well water samples from the Main Street residences were below all acceptable Massachusetts Drinking Water Regulations, except for pH at one well location, and were not impacted by any Facility-related contaminants.

Notwithstanding this, during private well sampling along Main Street, it was determined by Olin that all residences with private wells either used bottled water or pretreated the water prior to drinking it.

4.15.8 Town Well Sampling

On September 3, 1992, CRA and Coast-to-Coast Analytical Services, Inc. (formerly ABB) personnel collected samples from the Town of

Wilmington wells located to the west of the Facility. Groundwater samples were collected from the following five locations:

- Town Park Well;
- Butters Row Well #2 (in chamber);
- Butters Row Treatment Plant (after treatment);
- Chestnut Street Well #1 (in building); and
- Chestnut Street Well #1A (in chamber).

All samples were collected directly from sample ports.

A sample was later collected at Butters Row Well #1 (inside building) on September 10, 1993 when a broken shaft that had caused the well to be shut down during sampling of the above referenced wells was replaced.

All groundwater samples were submitted to the laboratory for analyses of the full TCL/TAL parameters plus hexavalent chromium, ammonia, NH_3, NO_3, TKN, cyanide, EDB, DBCP, chloride, sulphate, F, NO_2, TDS and pH. Field duplicate samples were collected at the Butters Row Well #2 and at the Chestnut Street #1 Well. Table 4.18 presents a summary of detected parameters in the Town of Wilmington well samples.

The organic substances detected before and after treatment were below the maximum concentration standards for drinking water established by the Federal Government.

The inorganic substances detected before treatment meet maximum concentration standards for drinking water established by the Federal Government except for iron, manganese and sodium. After treatment, the only exception was sodium which was above the State of Massachusetts standard.

5.0 SITE CONDITIONS

5.1 GENERAL

This section provides a detailed overview of the Site conditions based on CSA field activities as well as previous investigations completed prior to the CSA. This overview includes a discussion of:

1. topography;
2. geology;
3. groundwater hydrology;
4. surface water hydrology; and
5. buried materials.

For purposes of clarification, "Site" refers to the Facility grounds and surrounding region studied as part of the CSA, and "Facility" refers to that portion of the Site which lies within the property boundary.

5.2 SITE TOPOGRAPHY

The Facility is generally flat, sloping gently from north and south toward the center of the Facility. A low ridge runs along the south edge of the Facility, part of which is incorporated within the Sulphate Landfill. Trending in an east west direction through the center of the Facility, is a low lying area which is dissected by surface water drainage ditches. A small man made pond (approximately 1/2 acre in size) lies in the east central portion of the Facility. Shallow ditches run along the east and northwest sides of the Facility.

The northern 1/4 of the Facility is generally building or pavement covered. Between this area and the central low lying area is a grass covered area where the former lined lagoons had been previously located. A detailed discussion of Facility's vegetative cover, hydrology, soils and wildlife use is presented in Appendix H in the report entitled "Site Habitat Characterization, Olin Chemical Facility, 51 Eames Street, Wilmington, Massachusetts, March 1993" prepared by Wetlands Preservation, Inc.

The area to the immediate west of the Facility is generally flat between the Site and Highway 38 (Main Street). Land use in this area is commercial and industrial with pavement and building development covering a large portion of the area. West of Highway 38, the land slopes gradually towards the west into a large wetland complex. Maple Meadow Brook, a tributary of the Ipswich River, begins in and flows north across this wetland.

The area east and south of the Facility is generally flat with the exception of the former Woburn Town Dump, which is located immediately south of the Facility.

5.3 SITE GEOLOGY

5.3.1 General

Several previous studies have described Facility geologic conditions much of which is supported by CSA activities. The geologic units identified during the CSA include in descending order of age:

1. glacial outwash;
2. glacial ice contact deposits;
3. glacial till; and
4. bedrock (fine grained sedimentary gneiss).

Each geologic unit is described in the following subsection and includes a description of each unit's depositional history and geometric relationships. Geologic cross-sections A-A' through F-F', presented on Figures 5.1 through 5.6, illustrate the stratigraphy of the Facility. Plan 9, enclosed, illustrates the geologic cross-section locations. The Facility stratigraphy is consistent with the regional geology as discussed in Section 3.2 and is further described below.

5.3.2 Outwash

Glacial outwash was observed as the uppermost geologic unit over much of the eastern portion of the Facility and was also observed on the far western portion of the Facility. This unit is a stratified, fine to medium grained, moderately sorted, sand deposit containing scattered lenses of coarse sand and gravel. Unit thickness ranges from a few feet in well GW-47 to as much as 40 feet in well GW-48D along the east side of the Facility.

5.3.3 Ice Contact Deposits

Ice contact deposits occur as the upper most unit on the western side of the Facility and extend to the west into the large wetland underlying Maple Meadow Brook. This unit is a crudely stratified, poor to moderately sorted sand and gravel deposit. Boulders are common in the upper ten feet of the unit. Coarse sand and fine to medium gravel dominate the unit. Thickness of the ice contact deposits varies from a few feet on the Facility in well GW-54D to 70 feet in well GW-62D off the western side of the Facility near the Maple Meadow Brook wetland.

5.3.4 Glacial Till

Glacial till was encountered in boreholes mostly to the west of the Facility and was characteristically dense. The till consists of poorly sorted sand through boulder sized material with a minor component of silt and clay. The till was difficult to distinguish from the ice contact deposits because of the similar lack of sorting. The till was absent or only a few feet thick over most of the Site.

5.3.5 Bedrock

A fine-grained gneiss bedrock is also found at the surface and underlying the Site. Bedrock outcrops occur to the southwest of the Facility in the vicinity of Cook Avenue; on the southern portion of the Facility, near the Sulphate Landfill; southwest of monitoring well nest GW-19; south of monitoring well nest GW-51; and to the northwest of the Facility, in the vicinity of Janis Research. A general bedrock high trends across the Facility from southwest to northeast.

Based on outcrop and drill core observations, the gneiss is moderately to weakly fractured/jointed in its extreme upper portions.

Joint and fracture orientation measurements were acquired from several bedrock outcrop localities at the Site. Table 5.1 presents these measurements. These data show a strong consistency in joint/fracture orientation trending in a north-northeast direction. Joint/fracture planes also show a consistency in dip angle to the north varying from approximately 40 to nearly 90 degrees. Jointing and fracturing directional strikes tended to be consistent with the strike of relict bedding observed in the gneiss. Joint and fracture frequency diminishes with depth from the bedrock surface as few open fractures and or joints were observed in drill core beyond 10 feet below the top of the bedrock surface (see Appendix E for stratigraphic logs).

The bedrock surface topography was contoured using drilling and seismic geophysical data. Plan 10, enclosed, illustrates the topography of the bedrock surface. Three bedrock valleys were identified during the CSA investigation: the West Bedrock Valley, the East Bedrock Valley, and the Southwest Bedrock Valley. A description of each of these valleys is presented below and each valley is identified on Plan 10, enclosed.

West Bedrock Valley

The West Bedrock Valley begins just under the central portion of the Facility, and extends to the west northwest. At the Facility boundary, the valley lies at an elevation approximately 40 feet AMSL. The valley widens as it leaves the Facility boundary and eventually connects with a large bedrock valley which extends beneath the Maple Meadow Brook wetland. This valley in turn connects into the regionally extensive Ipswich River bedrock valley. The valley bottom slopes to the west and flattens out in the area just to the west of Highway 38 (Main Street). The approximate elevation of the valley at this location is 20 feet AMSL. Based on monitoring well installations, the lowest elevation of bedrock encountered was at an elevation of -13 feet AMSL at monitoring well location GW-65D.

East Bedrock Valley

The East Bedrock Valley begins in the central area of the Facility, and extends off Site to the east and south. It appears that the West and East Bedrock Valleys are connected by a high point located near the center of the Facility beneath the area of the unlined pits and Lake Poly. The East Bedrock Valley exits the Facility with a bedrock surface elevation of 40 feet AMSL.

Two former studies which characterize geologic conditions to the east and south of the Facility indicate that this bedrock valley turns to the south just east of the Facility, and joins in with the regionally extensive Aberjona River bedrock valley (Ecology and Environment 1980, Roux and Associates 1983).

Southwest Bedrock Valley

A third bedrock valley was characterized to the immediate southwest of the Wilmington Facility which begins just to the west of the

Sulphate Landfill and trends in a south to southwest direction. Well GW-40D, situated immediately southwest of the Sulphate Landfill, is located in the center of the Southwest Bedrock Valley. The bedrock at this location exhibits an elevation of 47 feet AMSL. Further to the southwest, at well GW-75D, the bedrock exhibits an elevation of 40.4 feet AMSL. Work completed by Ecology and Environment 1980, indicates that this valley extends to the south and joins the Aberjona River bedrock valley system.

5.3.6 Geologic Summary

Prior to the deposition of the glacial deposits, the bedrock surface was eroded into its current configuration by pre-glacial fluvial processes and also later by the glacial ice. The glacial till unit was the first unconsolidated unit deposited while the ice covered the landscape. The till was typically thin over most of the area and later was eroded and modified by glacial meltwater as the glacier margin retreated.

During glacial retreat, large volumes of meltwater and sediment were generated at the ice margin resulting in the deposition of a thick wedge of ice contact deposits. These deposits filled in many of the low depressions and bedrock valleys. As the ice margin further retreated meltwater streams deposited finer grained outwash on top of and interfingered with the ice contact deposits. The outwash further filled in low areas which were not completely filled by the ice contact deposits.

5.4 SITE HYDROGEOLOGY

5.4.1 General

The following subsections discuss the Site hydrogeologic conditions including a discussion of the hydrostratigraphic units

(Section 5.4.2), groundwater flow (Section 5.4.3) and an overview (Section 5.4.4).

5.4.2 Hydrostratigraphic Units

5.4.2.1 Glacial Deposits

The glacial ice contact deposits and outwash function as the single, principal hydrostratigraphic unit in the Site area. These sand and gravel deposits extend in all directions from the Facility and are connected into the region's major aquifer systems. The uppermost fractured portion of the bedrock surface beneath the Site is considered a part of this flow system. Below the upper fractured bedrock minor groundwater is transmitted along small fractures and joints.

The geometry of the sand and gravel aquifer is controlled by the configuration of the underlying bedrock topography. The aquifer is thin or absent where bedrock is at or near the surface, and is thickest in the bedrock valleys which dissect the Site area.

Beneath the Facility the sand and gravel aquifer is thickest in the east and west bedrock valleys and thins to the north and south. Outwash predominates as the major unit on the eastern portion of the Facility, and correspondingly, hydraulic conductivities tend to be relatively lower. In the East Bedrock Valley, ice contact deposits lie at depth below the outwash unit. On the western side of the Facility and to the west of the Facility into the Maple Meadow Brook wetland, ice contact deposits dominate the sand and gravel aquifer and correspondingly, hydraulic conductivities tend to be higher. The aquifer in this area becomes appreciably larger in volume in the region of the West Bedrock Valley. Drilling conducted on the west and north sides of the Maple Meadow Brook wetland indicate that outwash overlays and interfingers with the ice contact deposits.

Hydraulic conductivities values for the sand and gravel aquifer were calculated from CSA hydraulic testing and also were obtained from two references which characterized regional area groundwater conditions (IEP 1990 and USGS 1694). The CSA data are presented in Table 4.5 and the regional reference are discussed in Section 3.3.1. In general, hydraulic conductivities calculated for the glacial fluvial deposits fall in a range of 1×10^{-2} cm/sec to 1×10^{-4} cm/sec.

5.4.2.2 Bedrock

Four bedrock monitoring wells were installed as part of the CSA field activities. Bedrock core was obtained and examined during well construction to assess type and frequency of joints and fractures in the rock. In general, joint and fracture frequency diminishes considerably beyond ten feet of the bedrock surface. When pumped at low rates (1 to 3 gpm) all four bedrock monitoring wells drew down to a point of becoming nearly dry. Based on results of hydraulic conductivity testing, the hydraulic conductivity of the bedrock is estimated to be very low. Temperature logging conducted on bedrock wells indicated no apparent significant zones of groundwater contribution from fractures in the bedrock.

Since joint and fracture frequency diminishes at depth, and wells yielded low volumes of water, bedrock is not considered a significant source for groundwater in the region. Sufficient water, however, may be obtained for domestic purposes if wells cross cut enough joints and fractures (i.e. are drilled extremely deep). Because groundwater is available over a widespread part of the area from the sand and gravel aquifer, few wells tap the bedrock water. Bedrock supply wells are found only in places where both municipal water is not available, and the sand and gravel aquifer is thin or absent (e.g. Cook Avenue residences).

5.4.3 Groundwater Flow System

5.4.3.1 General

The CSA study area encompasses portions of two hydrologic basins with the divide located west and north of the Facility. The divide was characterized and supported by data obtained during the CSA and has also been identified and characterized in other regional studies (IEP 1990 and USGS 1694) and is illustrated as both a surface water and groundwater divide or hydraulic boundary. Plans 11 through 14, enclosed, present the groundwater elevations from two water level monitoring events, as measured in the monitoring wells assuming insignificant variation in the density of water in the wells. Also presented are the contours for shallow and deep groundwater from the two water level monitoring events and the location of the hydraulic boundary. In the area of the groundwater divide, horizontal hydraulic gradients are very low, with little difference in hydraulic head apparent. This is reflective of the relatively high hydraulic conductivities associated with coarse grained ice contact deposits and may be influenced by the groundwater withdrawal of Altron.

Because the gradients are so low, the exact position for the groundwater divide cannot be discerned, however, a zone which represents the region of the divide has been illustrated on the groundwater elevation plans (Plans 11 through 14). For the purposes of this report, the groundwater flow system (i.e. flow directions and flow rates) will be broken down into two areas:

- the area occupying the majority of the Facility and that area west of the Facility but east of the hydraulic boundary which is located within the Aberjona River hydrologic basin; and

- the area west of the hydraulic boundary which is located within the Ipswich River hydrologic basin.

5.4.3.2 East of Hydraulic Boundary

Groundwater Flow Patterns

In the area east of the hydraulic boundary, the general groundwater flow direction is from northwest to southeast across the main part of the Facility. In all water level monitoring events, a zone of radial flow centers on the north end of the Facility. This zone appears to indicate that a certain amount of aquifer recharge is occurring in this area. However, it should be noted that the aquifer is relatively thin in this area, and appears, based on the steepness of the horizontal hydraulic gradients, to be a zone of lower hydraulic conductivity.

On the northeast side of the Facility, groundwater is currently being pumped by Olin as discussed in Section 2.2. The pumping in this area influences the groundwater flow as seen by the steep gradients along the east side of the Facility.

Towards the center of the Facility, groundwater flows in general towards the south ditch, and on the west contours wrap around the ditch showing groundwater flow towards and discharging into the ditch. Visible groundwater discharge has been observed in the south ditch on the west side of the Facility over the entire 1 1/2-year course of the CSA investigation.

Groundwater contours in the vicinity of the NPDES discharge into the west ditch, show that a small amount of "mounding" may be influencing groundwater flow in this area.

Along the east side of the Facility groundwater flows towards the east ditch with a certain amount of discharge occurring based on observations of seeps by former Site investigators. Flow in the ditch also increases, generally, from north to south along the Facility boundary.

To the southwest of the Facility, a small groundwater divide is present. Here, groundwater flows from the extreme southwest portion of the Facility to the south.

West of the Facility boundary and towards the hydraulic boundary, the groundwater flows in a southeasterly direction towards the Facility and the south ditch. In this area, horizontal gradients are extremely flat reflecting the relatively high hydraulic conductivity associated with the coarse ice contact deposits which dominate the aquifer in this area.

Horizontal Hydraulic Gradients

The horizontal hydraulic gradients for the shallow and deep groundwater flow contours are essentially the same. Therefore, the horizontal hydraulic gradients discussed herein apply to flow across the entire aquifer.

At the northern end of the Facility, the horizontal hydraulic gradient is approximately 0.013 feet per feet and on the west side of the Facility is approximately 0.003 feet per feet. Extremely flat horizontal gradients (0.0003 feet per feet) were measured in the area between the hydraulic boundary and the Facility. In the center of the Facility, the horizontal hydraulic gradient on the east side is approximately 0.01 feet per feet. The steeper gradient on the east side of the divide is attributed to the pumping at Plant B and to lower hydraulic conductivity in this area.

Groundwater Flow Velocity

An estimate of the groundwater velocity in the glacial fluvial aquifer may be determined using the modified Darcy's Equation:

$$V = ki/n$$

where:

V = horizontal groundwater velocity
k = horizontal hydraulic conductivity
i = horizontal hydraulic gradient
n = effective porosity

As presented in Section 4.9, the horizontal hydraulic conductivity for the monitored intervals ranged from 7.7×10^{-2} to 9.7×10^{-4} cm/sec with a geometric mean of 7.9×10^{-3} cm/sec. An effective porosity of 0.25 may be assumed to be representative of the glacial fluvial deposits. Using the horizontal hydraulic conductivity geometric mean and a porosity of 0.25, the horizontal groundwater velocity was calculated to range from approximately 100 feet to 325 feet per year on the Facility. In the area west of the Facility where the horizontal gradients are low (0.0003 feet per feet), the groundwater flow velocity was calculated at 10 feet per year. The calculated flow velocities are estimates and may vary by an order of magnitude.

5.4.3.3 West of Hydraulic Boundary

Groundwater Flow Patterns

West of the hydraulic boundary, groundwater flow is directed to the west into the main portion of the regional aquifer. The Town of Wilmington pumping stations at Chestnut Street, Butters Row and the Town Park, function as discharge points for a portion of the groundwater in this area.

Maple Meadow Brook functions to some extent as a groundwater discharge point for at least a portion of the groundwater in the basin based on the observed baseflow emanating from the wetland. The recharge area for this system is largely occupied by the wetland itself which dominates this portion of the basin.

Horizontal Hydraulic Gradients

Horizontal hydraulic gradients were calculated west of the hydraulic boundary and ranged from 0.013 to 0.0003 feet per feet. The flat gradients were observed where the coarse ice contact deposits form the major hydrostratigraphic unit.

Groundwater Flow Velocity

Again, using the modified Darcy's Equation (see Section 5.4.3.2) an estimate of the groundwater velocity can be made. Using the horizontal hydraulic conductivity geometric mean and porosity values discussed in Section 5.4.3.2 and the horizontal gradients discussed above, the groundwater flow velocity west of the divide was calculated to range from 10 to 425 feet per year. These velocities are estimates and may vary by an order of magnitude.

5.5 SITE SURFACE WATER HYDROLOGY

5.5.1 General

The Facility contains a network of ditches which bound and run through the center of the Facility. These ditches have been labeled based on their location at the Facility and are described below. Plan 7, enclosed, shows the locations of these ditches.

5.5.2 West Ditch

The West Ditch begins along the northwest side of the Facility and drains to the south. The West Ditch functions as the point of discharge for Olin's NPDES outfall and enters the South Ditch on the west center side of the Facility. A second branch of the West Ditch begins in a network of collection trenches just west of the Facility boundary, parallels then joins the West Ditch just east of the Facility boundary. Base flow in the West Ditch appears to be minor.

5.5.3 South Ditch

The South Ditch begins at the Facility boundary along the west side. The South Ditch bisects the Facility, flows east across the center of the Facility and discharges off of the Facility into the East Ditch. A branch of the South Ditch parallels and then joins the South Ditch at the eastern Facility boundary. A constant base flow (groundwater discharge) is observed in the South Ditch network. Seeps are observed along the western portion of the ditch network. The branch of the South Ditch which enters from the south contains no base flow and functions principally as a surface water runoff feature.

5.5.4 East Ditch

The East Ditch begins to the north of the Facility, and flows south along the entire east side of the Facility paralleling the Boston and Maine Rail Line. Rainfall runs off the Facility by sheetflow runoff into surrounding wetlands which eventually empty into the East Ditch. South of the Facility, the East Ditch enters and exits a series of culverts eventually flowing into Halls Brook, a tributary of the Aberjona River.

A constant baseflow (groundwater discharge) was observed in the East Ditch over the 1 1/2-year period in which the CSA was conducted. The East Ditch also receives surface water runoff for a significant portion of the surrounding area.

5.6 SUMMARY OF BURIED WASTES

5.6.1 General

Twenty-nine test pit excavations in a total of 13 areas were conducted at the Facility to investigate magnetic anomalies identified on the Facility, as discussed in Section 4.4. Nine test pit excavations in a total of three areas were also conducted in the area of the warehouses at the Facility to investigate the potential for buried waste in this area, as discussed in Section 4.6. Waste was not encountered in ten of the 13 test pit areas excavated across the Facility and was not encountered in any of the three test pit areas excavated beneath the warehouses at the Facility. In some of the test pit areas, miscellaneous non-hazardous metal objects (i.e. fence posts) were excavated over identified magnetic anomalies. In other areas where magnetic anomalies were detected, shallow bedrock or large buried boulders were encountered. Magnetic minerals in the rock may have caused the magnetic anomalies at these locations.

Drummed waste, miscellaneous waste, and contaminated soil were encountered in three of the test pits at the locations shown on Plan 5, enclosed. The area where test pits 6, 7 and 8 were excavated, contained the most abundant buried drums. The area where test pit areas 18, 19 and 20 were excavated, contained a few miscellaneous drum parts, and contaminated soil. The area where test pit 21 was excavated, contained a mixture of scattered buried drums and miscellaneous debris. The following presents a brief description of areas where buried drums, drum parts and contaminated soil were encountered.

5.6.2 Encountered Waste Description

Test Pits 6, 7, 8

Drums were encountered throughout most of the area encompassing test pits 6, 7 and 8. Drums were observed up to three deep in a portion of the area. Almost all drums were deteriorated and were of very poor integrity. The drums contained miscellaneous compounds tentatively identified by the former Facility manager as Opex, Kempore and phenolic resins. In addition, a blue solid substance and a gray greasy viscous substance were also observed. Other miscellaneous wastes such as hard phenolic resins, jars of unknown compounds, unidentified loose compounds and tentatively Opex and Kempore were also encountered in these test pits.

Test Pits 18, 19, 20

A few crushed drums and drum parts were encountered in this area. Miscellaneous rubbish was also encountered. Soil contamination was visually evident and also indicated by an OVA. The odor was tentatively identified by former Facility personnel as diphenylamine or "Plant B odor". Most wastes encountered, however, were identified as rubbish.

Test Pit 21

Test pit 21 was excavated in an area not identified by a magnetic anomaly. Based on information provided by the former Facility manager, it was determined that waste may be buried in that area. Excavation of test pit 21 confirmed that buried drums, laboratory bottles and miscellaneous wastes identified as a blue substance, a gray viscous substance, rubbish and tentatively Opex and Kempore were buried in that area. Scattered drums which were encountered were very deteriorated and/or crushed. Drums contained a blue substance, a gray substance, phenolic resins, and tentatively Kempore.

5.6.3 Summary

Buried wastes were encountered in three of the 22 areas that were identified to potentially contain buried wastes. These areas are identified on Plan 5, enclosed. Test pit areas 6, 7 and 8 contained extensive buried drums and miscellaneous wastes. Test pits 18, 19, 20 contained little drum waste but did contain contaminated soil and rubbish. Test pit area 21 contained scattered buried drums and miscellaneous wastes.

6.0 SITE CHARACTERIZATION

Extensive sampling of surface and subsurface soils, groundwater, surface water and sediments was conducted during the CSA Phase II field activities. The objective of the CSA Phase II investigation was to characterize the type and quantity of oil or hazardous materials released at or from the Facility in order to characterize and evaluate the risk of harm, if any, that the Facility poses to health, safety, public welfare and the environment. This section, therefore, provides a discussion of the results of the CSA Phase II sampling program and a characterization of the materials released at or from the Facility. This section also discusses the aspects of surface water and groundwater hydrology affecting the distribution and transport of the Facility-related compounds. As discussed in Section 1.0, ABB has prepared the CSA Phase II Risk Assessment Report which characterizes and evaluates the risk of harm, if any, that the Facility poses to health, safety, public welfare and the environment. The CSA Phase II Risk Assessment Report combined with this CSA Phase II Field Investigation Report provide the basis to develop remedial response alternatives, as required under 310 CRM 40.546.

6.1 CSA DATA BASE

The CSA Phase II field investigation data base consists of physical information described and documented in Sections 2.0 through 5.0 and the analytical results of samples collected from the various media.

The samples collected during the CSA Phase II field investigation activities are discussed in Section 4.15 and Table 4.1 provides a chronological summary of the dates when samples were collected. All samples collected for chemical analyses were analyzed by Coast-to-Coast Analytical Services, Inc., (formerly ABB) of Westbrook, Maine certified by Massachusetts D.E.P. ID number ME019 and meeting the Minimum Standards for Analytical Data for Remedial Response Actions under

MGLc.21.E, Policy #WSC-300-89. These samples include, but are not limited to:

i) eight test pit soil/drum samples analyzed for Target Compound List (TCL) Volatile Organic Compounds (VOCs), TCL Semi-Volatile Organic Compounds (SVOCs), TCL Pesticides/PCBs, Target Analyte List (TAL) parameters, 2,4,4-Trimethyl-1-Pentene (244TM1P), 2,4,4-Trimethyl-2-Pentene (244TM2P), ammonia, chloride and sulphate (see Table 4.2);

ii) ten composite surface soil samples analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides/PCBs, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (see Table 4.17);

iii) one composite surface soil sample analyzed for total chromium and hexavalent chromium;

iv) four composite hand auger shallow subsurface soil samples (upper two feet) analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides/PCBs, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (see Table 4.17);

v) 40 subsurface soil samples analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides/PCBs, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (see Table 4.16);

vi) one background surface soil sample and one background subsurface soil sample from the same borehole location (BH-41) analyzed for TCL Polynuclear Aromatic Hydrocarbons (PAHs) and TAL parameters;

vii) 62 groundwater samples analyzed for indicator parameters ammonia, chromium, chloride and sulphate (see Table 4.8);

viii) 11 groundwater samples analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides/PCBs, TAL parameters, 244TM1P, 244 TM2P, ammonia, chloride and sulphate plus an additional groundwater sample from one location for PCB analyses (see Table 4.9);

ix) two rounds of groundwater samples analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (first round consisted of 114 samples and second round consisted of 136 samples including QA/QC requirements), during the first round, 19 samples for specific gravity analyses and 11 samples for hexavalent chromium, and during the second round, 18 samples for specific gravity analyses and 11 samples for hexavalent chromium were also collected (see Tables 4.10 and 4.11);

x) two rounds of surface water samples analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (first round consisted of 22 samples and second round consisted of 36 samples including QA/QC requirements), during the first round 2 samples for hexavalent chromium analysis and during the second round 6 samples for hexavalent chromium analysis were also collected (see Tables 4.12 and 4.13); and

xi) two rounds of sediment samples analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (first round consisted of 25 samples and second round consisted of 35 samples including QA/QC requirements), during the first round, 2 samples for hexavalent chromium analysis and during the second round 8 samples for hexavalent chromium analyses were also collected (see Tables 4.14 and 4.15).

Analyses of the foregoing samples were performed by Coast-to-Coast using the following methods:

Matrix	*Parameter*	*Analytical Method (1)*	*Method Reference*
Groundwater	TCL-VOCs	8240	1
Surface Water/	TCL-BNAs	8270	1
Soil/Sediment/	TCL-Pesticides/PCBs	8080	1
Drummed Waste	TAL-Metals	6010/7000 series	1
	Cyanide	9010	1
	General Chemistry Parameters		
	Sulphate	9038	1
	Chloride	9250/9251	1
	Ammonia	350.2 (modified)	2

References:

(1) Test Methods for Evaluating Solid Waste, USEPA SW-846, 3rd Edition, November 1986.
(2) "Methods for Chemical Analysis of Water and Wastes", EPA-600/04-79-020, Revised, March 1983.

Complete analytical data summaries are presented in Appendix L. Appendix L presents summary tables of detected parameters in each media, summary tables of frequency of detections, maximum and minimum detected concentrations and average detected concentrations, and complete summary tables (including detected and non-detected parameters) for each media.

The laboratory reports were assessed and validated by CRA's quality assurance/quality control (QA/QC) officer based upon a review of standard quality control criteria established by the QAPP (Appendix F of CSA Work Plan). The data assessment and validation reports for all CSA Phase II Field Investigation activities data are presented in Appendix M.

On the basis of the formal data validation identified in the foregoing discussion, all data presented on the tables have been qualified as appropriate.

6.2 CSA DATA PRESENTATION

As discussed above, Appendix L presents complete summary tables for analytical data generated during the course of the CSA Phase II Field Investigation. Based upon a review of the analytical data and due to the size of the data base it was decided that for each media (i.e. surface soil, subsurface soil, groundwater, surface water and sediment) the following data would be presented on plans for each media:

- Total Halogenated Volatile Organic Compounds (HVOC);
- Total of 244TM1P and 244TM2P (Pentenes);
- Total Benzene, Toluene, Ethylbenzene & Xylene (BTEX);
- Total Polynuclear Aromatic Hydrocarbons (PAHs);
- Total Phthalate Isomers (PHTH);
- Total Phenolic Compounds (PHE);
- N-Nitrosodiphenylamine (N-NDPA);
- Ammonia;
- Chloride;
- Chromium; and
- Sulphate.

For surface water and sediments, aluminum is also presented on each respective plan.

6.3 DRUM WASTE CHEMISTRY

6.3.1 General

As discussed in Section 5.6, drummed waste, miscellaneous waste, and visibly contaminated soils were encountered in three of the 16 test pit areas excavated at the Facility. The location of these areas are shown on Plan 5, enclosed. The area where test pits 6, 7 and 8 were excavated, contained the most abundant buried drums. The area where test pits 18, 19 and 20 were excavated, contained a few miscellaneous drum parts, and contaminated soil. The area where test pit 21 was excavated, contained a mixture of scattered buried drums and miscellaneous debris. Section 5.6.2 presents a more detailed description of the wastes encountered in the test pit excavations. Section 4.4 discusses the test pit excavation protocols, which included the collection of eight drum and/or soil samples for chemical analyses. As summarized in Section 6.1, eight test pit soil/drum samples were collected and analyzed for TCL VOCs, TCL SVOCs, TAL parameters, TCL Pesticides/PCBs, 244TM1P, 244TM2P, ammonia, chloride and sulphate.

A summary of the drum and/or soil samples collected for chemical analyses is presented in Table 4.2. A summary of the following data is presented in Appendix L:

- Tab 7 Summary of Detected Test Pit Data;
- Tab 8 Average Detected Concentrations for Test Pit Data (includes frequency of detection); and
- Tab 17 Summary of Test Pit Data.

The following subsection presents a summary of the analytical data for the areas where buried drums, drum parts and contaminated soils were encountered.

6.3.2 Test Pit Characterization

6.3.2.1 Test Pits 6, 7, 8

Drums were encountered throughout most of the area encompassing test pits 6, 7 and 8. As summarized in Table 4.2, one drum sample was collected from test pit 6 and two drum samples plus one duplicate sample were collected from test pit 8.

VOCs

A review of the VOC data presented in Appendix L, Tab 7, shows that seven volatile organic compounds (VOCs) were detected in the four drum samples. The maximum detected concentrations were 0.88 mg/kg for Toluene and 0.6 mg/kg for 2-Hexanone (MNBK). The other five VOCs were all detected at concentrations of less than 0.1 mg/kg.

SVOCs

A review of the SVOC data presented in Appendix L, Tab 7, shows that two semi-volatile organic compounds (SVOCs) were detected in the four drum samples. Bis(2-ethylhexyl)phthalate (B2EHP) was detected in two samples at concentrations of 16 mg/kg and 4.4 mg/kg and N-Nitrosodiphenylamine (NNDPA) was detected in one sample at a concentration of 21,000 mg/kg. As summarized in Table 2.1, NNDPA and phthalate plasticizers were products produced at the Facility.

Pesticides/PCBs

No PCBs or pesticides were detected in the four drum samples.

Inorganics

A comparison of the inorganic data presented in Appendix L, Tab 7 to Site-specific background data (see Appendix L, Tab 20), indicates that the following inorganic compounds in the four drum samples exhibit concentrations above background for the Site:

Compound	*Max. Detected Co... (mg/kg)*
Ammonia	2,100J
Calcium	27,000
Chloride	25,000J
Chromium (total)	90

Compound	*Max. Detected Conc. (mg/kg)*
Iron	28,000
Potassium	16,000
Sodium	4,800
Sulphate	5,600J

A comparison of the chromium, iron and potassium concentrations to the natural background concentration ranges of these parameters in soils for the eastern United States (see Table 6.1) indicates that all three parameter concentrations are within the natural background concentration ranges.

6.3.2.2 Test Pits 18, 19, 20

Limited excavation revealed remnants of an undetermined number of crushed drums and drum parts and miscellaneous rubbish in the area encompassing test pits 18, 19 and 20. As summarized in Table 4.2, one soil sample was collected from test pit 19.

VOCs

A review of the VOC data presented in Appendix L, Tab 7, shows that four VOCs, all at concentrations less than 0.002 mg/kg were detected in the soil sample.

SVOCs

With the exception of Phenol at a concentration of 5.3J mg/kg and N-Nitrosodipropylamine (NNDNPA) at a concentration of 1.6J mg/kg, no other SVOCs were detected in the soil sample.

Pesticides/PCBs

No PCBs or pesticides were detected in the soil sample.

Inorganics

With the exception of Ammonia at a concentration of 490 mg/kg, no other inorganics were detected in the soil sample at concentrations above background for the Site.

6.3.2.3 Test Pit 21

Scattered drums/drum parts, laboratory bottles and miscellaneous wastes were encountered in the area of test pit 21. As summarized in Table 4.2, one drum sample and one soil sample were collected from test pit 21.

VOCs

A review of the VOC data presented in Appendix L, Tab 7, shows that three VOCs were detected in the drum sample and one VOC was detected in the soil sample. With the exception of Acetone at a concentration of 0.25 mg/kg, the other VOCs were detected at concentrations less than 0.004 mg/kg.

SVOCs

In the drum sample, various SVOCs were detected including chlorobenzenes (maximum detected was 1,4-Dichlorobenzene at 1.2 mg/kg), phenolic compounds (maximum detected was 4-Methylphenol at 8.8 mg/kg), phthalate isomers (maximum detected was B2EHP at 2.5 mg/kg) and NNDPA at 1.5 mg/kg. In the soil sample, B2EHP was detected at a concentration of 1,100J mg/kg

Pesticides/PCBs

With the exception of Endosulfan I at 0.036J mg/kg in the soil sample, no other pesticides or PCBs were detected.

Inorganics

A comparison of the inorganic data presented in Appendix L, Tab 7 to Site-specific background data (see Appendix L, Tab 20), indicates that the following inorganic compounds in the two samples exhibit elevated concentrations above background for the Site:

Compound	*Concentration (mg/kg)* Soil	Drum
Ammonia	47	100
Calcium	160,000	5000
Iron	--	40,000J
Sulphate	29,000	--

The concentration for iron is, however, within its natural background concentration range in soils for the eastern United States (see Table 6.1).

6.3.2 Test Pit Waste Summary

Based on the test pit excavation program, there are three areas at the Facility which exhibited evidence of buried drum waste, miscellaneous waste and visibly contaminated soils. During excavation of these areas, a previous plant manager tentatively identified materials within the test pits of the three areas as Opex, Kempore, Phenolic resins, and Plant B material (diphenylamine) (previous processes at the Facility, see Table 2.1).

The analytical data collected during the test pit excavations indicated that three organic compounds B2EHP, NNDPA and

NNDNPA and inorganic compounds ammonia, calcium, chloride, chromium, iron, potassium, sodium and sulphate were the major parameters detected in the drum and/or soil samples.

The B2EHP, NNDPA and NNDNPA all exhibit high partitioning coefficients (K_{OC}) (see Appendix K), and will strongly adsorb to organic material in soils. Therefore, they will have a low potential for partitioning to the groundwater and are virtually immobile in the soils. However, inorganic compounds ammonia, chloride and sulphate exhibit high solubilities. Ammonia is readily soluble in water (see Appendix K), and therefore, will have a high potential for partitioning to the groundwater. Chlorides and sulphates, which are normal soil constituents, exist primarily as anions in a wide range of pH. These anions are readily soluble in water although differing complexing tendencies will depend on soil chemistry such as pH and organic carbon content. The other inorganic compounds are virtually immobile in soils under normal conditions (i.e. neutral pH), but their leachability from the soil, would increase with decreasing pH conditions. Appendix K presents a detailed discussion pertaining to the fate and transport of the above compounds.

6.4 SOIL CHEMISTRY

6.4.1 General

As discussed in Sections 4.15.4 and 4.15.5, extensive subsurface and surface soil sampling programs for chemical analysis were conducted as part of the CSA Phase II field activities. The surface soil sampling locations are shown on Figure 4.2. The locations where the subsurface soil samples were collected are shown on Plan 8, enclosed.

Summaries of subsurface soil and surface soil samples collected for chemical analyses are presented in Tables 4.16 and 4.17, respectively. A summary of the following data is presented in Appendix L:

Surface Soils

- Tab 5 Summary of Detected Surface Soil Data;
- Tab 6 Average Detected Concentrations for Surface Soil Data; and
- Tab 16 Summary of Surface Soil Data.

Subsurface Soils

- Tab 3 Summary of Detected Subsurface Soil Data;
- Tab 4 Average Detected Concentrations for Subsurface Soil Data; and
- Tab 15 Summary of Subsurface Soil Data.

The following subsections present a summary of the analytical data for Facility surface soils and subsurface soils.

6.4.2 Surface Soil Characterization

6.4.2.1 General

As summarized in Section 6.1, ten composite surface soil samples were collected and analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides/PCBs, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (see Table 4.17). In addition, four composite hand auger shallow subsurface soil samples (upper two feet) were collected and analyzed for TCL TCL VOCs, TCL SVOCs, TCL Pesticides/PCBs, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate. An additional composite hand auger shallow subsurface soil sample was collected for total chromium and hexavalent chromium analysis. One background surface soil sample was also collected and analyzed for TCL PAHs and TAL parameters.

The ten composite surface soil samples each consisted of four discrete samples which were composited by the laboratory and the four composite shallow hand auger samples each consisted of three discrete samples which were also composited by the laboratory (see Section 4.15.5). The additional composite hand auger sample collected for total chromium and hexavalent chromium analysis consisted of two discrete samples which were composited in the field. The background surface soil sample was a discrete shallow split-spoon sample collected during the installation of well nest GW-67, located approximately 1,400 feet west of the Facility.

The following subsections present a summary of the analytical data for the ten composite surface soil samples, the four composite hand auger samples and the single chromium speciation sample

6.4.2.2 Surface Soil Samples - Areas 1 to 10

VOCs

A review of the VOC data presented on Plan 34, enclosed, and in Appendix L, Tab 5, shows sporadic and infrequent detection of only five VOCs in the ten composite surface soil samples. Toluene (MEC6H5) was detected in four of the ten samples but all detections were at concentrations less than 0.004J mg/kg. Methylene Chloride (C2CL2), 244TM1P and 244TM2P were detected in one sample at concentrations of 0.036 mg/kg, 0.014 mg/kg and 0.005J mg/kg, respectively.

SVOCs

A review of the SVOC data presented on Plan 34, enclosed, and in Appendix L, Tab 5, shows that various PAHs and phthalate isomers were detected in the ten composite surface soil samples. The maximum concentrations of PAHs detected were Chrysene (CHRY) at 0.64J mg/kg and Benzo(b)Fluoranthene (BBFANT) at 0.56J mg/kg. Most other PAHs were detected at concentrations less than 0.2 mg/kg. A comparison of the PAHs in the surface soil samples to Site-specific background data (see

Appendix L, Tab 20) indicates that all the PAHs are above background for the Site. However, as noted in Appendix K, PAHs are ubiquitous in the environment and the levels found in the Facility surface soil samples parallel those for industrial and urban development. A comparison of the PAHs in the surface soils to typical background concentrations in rural, agricultural, and urban soils (see Table K.5, Appendix K) shows that the PAHs detected in the surface soils at the Site are well below typical urban soil concentrations and within typical agricultural soil concentrations. The prevalent phthalate isomer detected in the soils was B2EHP, which was detected in all ten surface soil samples, at concentrations ranging from 0.066J mg/kg to 89 mg/kg.

Pesticides/PCBs

A review of the Pesticide/PCB data presented on Plan 34, enclosed, and in Appendix L, Tab 5 shows infrequent detection of the following three pesticides: 4,4'-DDD, 4,4'-DDE and 4,4'-DDT. All three were detected in Area 4 at concentrations of 0.039J mg/kg, 0.049J mg/kg and 0.68J mg/kg, respectively and only 4,4'-DDT was detected in Area 5 at a concentration of 0.061J mg/kg. Both of these areas (see Plan 34) are situated immediately adjacent to Eames Street. No PCBs were detected in any of the samples.

Inorganics

A comparison of the inorganic data presented on Plan 34, enclosed, and in Appendix L, Tab 5 to Site-specific background data (see Appendix L, Tab 20), indicates that the following inorganic compounds in the surface soil samples exhibit sporadic elevated concentrations above background for the Site:

Compound	*Max. Detected Conc. (mg/kg)*
Ammonia	170 (all Areas)
Calcium	534,000 (Area 8 only)
Chromium (total)	750 (Area 1 and 8 only)
Sulphate	28,000J (Area 1 and 8 only)

As shown above, with the exception of ammonia present in all areas, the other three inorganic compounds exhibited elevated concentrations in Area 1 and/or Area 8 (see Plan 34).

6.4.2.3 Hand Auger Samples

As discussed in Section 4.15.5, a total of four composite hand auger samples of Site surface soils were collected. Three composite hand-auger samples were collected from areas exhibiting visual signs of contamination (SWMU No. 27, SWMU No. 30 and SWMU No. 33). An additional composite hand-auger sample was collected from the area of SWMU No. 25 at which earlier fuel oil spills had occurred. All samples were collected within the upper two feet of the ground surface.

Based on initial sampling results, a second composite sample was collected from the area of SWMU No. 27 for chromium speciation analyses.

VOCs

A review of the VOC data presented in Appendix L, Tab 5, shows sporadic and infrequent detection of seven VOCs in the four hand-auger samples. SWMU No. 27 along the West Ditch (see Figure 4.2) detected six VOCs which included 244TM1P (0.3J mg/kg), 244TM2P (0.039 mg/kg), Acetone (0.093J mg/kg), C2CL2 (0.047J mg/kg), Tetrachloroethene (TCLEE) (0.073J mg/kg) and MEC6H5 (0.015J mg/kg). The sample from SWMU No. 30 (South Ditch) exhibited detected concentrations of only three VOCs, all at concentrations less than 0.02 mg/kg and the sample from SWMU No. 33 (near well nest GW-55) exhibited detected concentrations of two VOCs, both at concentrations of 0.001J mg/kg. The sample from SWMU No. 25 exhibited no detectable VOC concentrations.

SVOCs

A review of the SVOC data presented in Appendix L, Tab 5, shows that phthalate isomers were detected in three of the four hand-auger samples. B2EHP was detected at SWMU No. 27 at a concentration of 5,500J mg/k, at SWMU No. 33 at a concentration of 34J mg/kg and at SWMU No. 25 at a concentration of 2.2 mg/kg.

Pesticides/PCBs

A review of the Pesticide/PCB data presented in Appendix L, Tab 5, shows that only 4,4'-DDE and Endosulfan II (BENSLF) were detected at SWMU No. 30 at concentrations of 1.7J mg/kg and 0.34J mg/kg, respectively and that Alpha-BHC (ABHC) and BENSLF were detected at SWMU No. 27 at concentrations of 0.22J mg/kg and 0.092J mg/kg, respectively. No PCBs were detected in any of the samples.

Inorganics

A comparison of the inorganic data presented in Appendix L, Tab 5 to Site-specific background data (BH41 at GW-67 well nest) presented in Appendix L, Tab 20, indicates that the following inorganic compounds in the hand-auger samples exhibited sporadic elevated concentrations above background for the Site:

	Concentration (mg/kg)			
Compound	*SWMU No. 25*	*SWMU No. 27*	*SWMU No. 30*	*SWMU No. 33*
Aluminum	--	--	--	59,000
Ammonia	13	670J	400	300
Chromium (total)	19	4,500	3,600	5,000
Iron	--	--	--	100,000
Nickel	12	--	--	67
Sulphate	--	--	1,200J	2,400J
Zinc	21	--	--	180

As shown above, elevated levels of ammonia and chromium are exhibited at three locations and sulphate at two locations. The elevated levels of the other inorganics, aluminum, iron, nickel and zinc at SWMU No. 33, are all within natural background concentration ranges for metals in soils of the eastern United States (see Table 6.1).

Chromium Speciation

Chemical speciation was conducted at SWMU No. 27 to determine the ratio of total chromium to hexavalent chromium (Cr VI) within the surface soil. A ratio of approximately six percent Cr VI to total chromium was observed.

6.4.2.4 Surface Soil Characterization Summary

The analytical data collected during the surface soil/hand-auger sampling program indicated that B2EHP and inorganic compounds ammonia, chromium and sulphate were the major parameters detected in the surface soils.

As discussed for test pit samples, B2EHP exhibits a high K_{OC} value and will strongly adsorb to organic material in soils. Therefore, it has a very low potential for partitioning to the groundwater and will be virtually immobile in the soils. However, the migration of B2EHP may occur via sediment transport in surface water runoff. The inorganic compounds ammonia and sulphate exhibit high solubilities and will therefore exhibit a high potential for partitioning to groundwater and/or surface water. Chromium is considered to be virtually bound to the soils under normal conditions (i.e. neutral pH), but its leachability from the soil would increase with decreasing pH conditions. Appendix K presents a detailed discussion pertaining to the fate and transport of the above compounds.

6.4.3 Subsurface Soil Characterization

6.4.3.1 General

As summarized in Section 6.1, 40 subsurface soil samples were collected and analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides/PCBs, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (see Table 4.16) and one background subsurface soil sample was collected and analyzed for TCL PAHs and TAL parameters. The background subsurface soil sample was collected during the installation of well nest GW-67, located approximately 1,400 feet west of the Facility.

6.4.3.2 Characterization

VOCs

A review of the VOC data presented on Plan 15, enclosed, and in Appendix L, Tab 3, shows that 244TM1P, 244TM2P, Toluene, 2-Butanone (MEK), 2-Hexanone (MNBK) and Acetone were detected across the Facility.

244TM1P was detected in 33 of 40 samples and 244TM2P was detected in 30 of 40 samples. The concentration of 244TM1P ranged from 0.002 mg/kg to 7.0 mg/kg with an average detected concentration of approximately 0.68 mg/kg. The concentration of 244TM2P ranged from 0.001 mg/kg to 5.1 mg/kg with an average detected concentration of approximately 0.44 mg/kg. The highest levels of both 244TM1P and 244TM2P were detected in borehole locations BH9, BH11, BH15, BH17, BH23, BH25, BH26 and BH34. BH9 is located in the area of a former lagoon (SWMU No. 9). BH11 and BH15 are located adjacent to the southwest corner of the warehouse, in the vicinity SWMU No. 18 and SWMU No. 24 (see Figure 4.2). BH17 is located in the former Lake Poly area (SWMU No. 14). BH23 and BH25 are located in the area east of Plant D (SWMU No. 26). BH34 is located in the Plant B area (SWMU No. 13 and 23) and BH26 is located in the area the former by-product HCl tank (SWMU No. 3). The data shows that 244TM1P and 244TM2P are present in subsurface soils across the Facility.

Toluene, MEK, MNBK and Acetone were detected in 24 of 40 samples, 16 of 40 samples, 12 of 40 samples and 11 of 40 samples, respectively. The detected concentrations ranged as follows:

	Detected Concentration (mg/kg)		
Compound	***Minimum***	***Maximum***	***Average***
Toluene	0.0008	4.8	0.22
MEK	0.0006	0.49	0.04
MNBK	0.001	3.8	0.34
Acetone	0.016	17.0	1.7

The maximum concentrations of MEK and Acetone were detected in the area of the former lagoons (SWMU No. 9 and 10). The maximum concentrations of Toluene and MNBK plus elevated levels of ethylbenzene (ETC6H5) at 2.3 mg/kg and Styrene at 3.3 mg/kg were detected at BH15 (SWMU No. 18).

Other VOCs detected in the soil samples were sporadic and infrequent at concentrations ranging from 0.0005 mg/kg to 0.035 mg/kg, with the exception of a single hit of methylene chloride at 2.0 mg/kg.

SVOCs

A review of the SVOC data presented on Plan 15, enclosed, and in Appendix L, Tab 3, shows that phthalate isomers and N-Nitrosodiphenylamine (NNDPA) were the most prevalent SVOCs detected in the subsurface soils.

The phthalate isomers detected included B2EHP (29 out of 40 samples), Butyl Benzylphthalate (BBZP) (10 out of 40 samples) and Di-n-Octylphthalate (DNBP) (16 out of 40 samples). The B2EHP was detected the most frequently and at the highest concentrations of 0.1 mg/kg to 1,200 mg/kg with an average detected concentration of approximately 390 mg/kg. Similar to the presence of 244TM1P and 244TM2P, phthalate isomers, although most prevalent in the vicinity of the former Lake Poly area (SWMU No. 14), are located in subsurface soils throughout the Facility.

NNDPA was detected in 13 of 40 samples at concentrations ranging from 0.15 mg/kg to 3,400 mg/kg with an average detected concentration of approximately 265 mg/kg. Similar to the phthalate isomers, NNDPA, although more prevalent in the former Lake Poly area (SWMU No. 14), is located in subsurface soils throughout the Facility.

Pesticides/PCBs

A review of the Pesticide/PCB data presented in Appendix L, Tab 3, shows that five pesticides were detected in one sample (BH12) and two pesticides in another sample (BH3). All detected concentrations were less than 0.15 mg/kg. PCBs were not detected in any subsurface soil samples.

Inorganics

A comparison of the inorganic data presented on Plan 15, enclosed, and in Appendix L, Tab 3, to Site-specific background data (BH41 at GW-67 well nest) presented in Appendix L, Tab 20, indicates that the following inorganic compounds in the subsurface soil samples exhibited elevated concentrations above background for the Site:

Compound	*Max. Detected Conc. (mg/kg)*
Ammonia	400
Calcium	16,000
Chloride	170
Chromium (total)	2,400
Mercury	0.3
Potassium	2,000
Sodium	440
Sulphate	33,000

With the exception of mercury which was detected in three samples and chloride which was detected in 17 of 40 samples, all other above listed inorganic parameters were located in subsurface soil, above Site-specific background levels, throughout the Facility. As with the VOCs and SVOCs, the highest concentration of the inorganics were detected in the vicinity of former Lake Poly (SWMU No. 14).

6.4.3.3 Subsurface Soil Characterization Summary

The analytical data collected during the subsurface sampling program indicated that the following compounds were detected in subsurface soils throughout the Facility:

VOCs: 244TM1P, 244TM2P, Toluene, 2-Butanone, 2-Hexanone and Acetone;

SVOCs: Bis(2-ethylhexyl)Phthalate (B2EHP), Butyl Benzylphthalate (BBZP), Di-n-Octylphthalate (DNBP) and N-Nitrosodiphenylamine (NNDPA); and

Inorganics: Ammonia, Calcium, Chromium (total), Potassium, Sodium and Sulphate

The highest concentrations of all the above compounds were detected in the vicinity of former Lake Poly (SWMU No. 14).

The atmospheric fate and transport mechanisms for 244TM1P and 244TM2P is characterized by a high vapor pressure of 77.5 mm Hg at 38°C. This indicates potentially significant volatility from soil, surface water and groundwater. There are no available data found regarding water solubility but these compounds are known to be soluble in organic solvents such as benzene and chloroform. Soil adsorption cannot be predicted due to the lack of available K_{OC} values in literature (see Appendix K).

As discussed for test pit samples, the phthalate isomers, B2EHP, BBZP and DNBP and NNDPA all exhibit high K_{OC} values and will strongly adsorb to organic material in soils. Therefore, they have a very low potential for partitioning to the groundwater and will be virtually immobile in the soils. However, the migration of phthalate isomers and NNDPA may occur via sediment transport in surface water runoff. The inorganic compounds ammonia, calcium, potassium, sodium and sulphate all exhibit high solubilities and will, therefore, exhibit a high potential for partitioning to groundwater and/or surface water. Chromium is considered to be virtually bound to the soils under normal conditions (i.e. neutral pH), but its leachability from the soil will increase with decreasing pH conditions. Appendix K presents a detailed discussion pertaining to fate and transport of the above compounds.

6.5 GROUNDWATER CHEMISTRY

6.5.1 General

As discussed in Section 4.15.1, extensive groundwater sampling programs for chemical analyses were conducted as part of the CSA Phase II field activities. As summarized in Section 6.1, 61 investigative groundwater samples were collected and analyzed for indicator parameters ammonia, chromium, chloride and sulphate and 11 investigative groundwater samples were collected and analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides/PCBs, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate plus one additional investigative groundwater sample from one location for PCB analyses. Subsequently, two rounds of groundwater samples were collected and analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (first round consisted of 114 investigative samples and second round consisted of 136 investigative samples including QA/QC requirements). During the first round, 19 investigative samples were collected for specific gravity analyses and 11 investigative samples were collected for hexavalent chromium analyses. During the second round, 18 investigative samples were collected for specific gravity analyses and 11 samples were collected for hexavalent chromium analyses. The locations of all Facility and Site monitoring wells are shown on Plan 3, enclosed.

Summaries of the groundwater samples collected for chemical analyses are presented in Table 4.8 (Groundwater Indicator Sampling Summary), Table 4.9 (Full Groundwater TCL/TAL Parameter Sampling Summary), Table 4.10 (First Round Groundwater Sampling Summary) and Table 4.11 (Second Round Groundwater Sampling Summary). A summary of the following data is presented in Appendix L:

- Tab 11 Summary of Detected Round 1 and 2 Groundwater Data;
- Tab 12 Average Detected Concentrations for Round 1 and 2 Groundwater Data;
- Tab 21 Summary of Groundwater Data Previous to Round 1;
- Tab 22 Summary of Round 1 and 2 Groundwater Data; and
- Tab 25 Summary of Non-Aqueous Phase Groundwater Data.

Supplementing the first and second groundwater monitoring rounds was the EM geophysical well logging (see Section 4.12) which was used to aid in determining the vertical extent of the contaminated plume within the aquifer.

The following subsections present a summary of the analytical data for groundwater at the Site.

6.5.2 Groundwater Sampling Prior to Rounds 1 and 2

6.5.2.1 Indicator Parameter Analyses

As discussed in Section 4.15.1, an initial set of groundwater samples, consisting of 61 samples was collected from existing and newly installed monitoring wells. The samples were analyzed for groundwater indicator parameters ammonia, chromium (total), sulphate and chloride (see Table 4.8). These wells were sampled to assist in tracking the identified groundwater plume off the Facility such that additional CSA monitoring wells, if required, could be located. The data from these samples are presented in Appendix L, Tab 21.

These data have not been taken into account in the discussion which follows of groundwater chemistry at the Site or for conducting the risk assessment. The more complete data base set generated during Round 1 and 2 groundwater sampling (see Section 6.5.3) will be used for these purposes. It is to be noted that the indicator parameter data are consistent with the Round 1 and 2 groundwater data.

6.5.2.2 Full Parameter Analyses

In accordance with the CSA Work Plan, 11 Site wells were selected, based on historic data and indicator parameter analyses, to be sampled and analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides/PCBs [illegible] parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (see Table 4.9). The data for these samples are presented in Appendix L, Tab 21.

These data were reviewed such that a Site Specific Parameter List (SSPL) could be selected for further and more extensive groundwater, surface water and sediment sampling and analyses. The SSPL selected included all of the above parameters (see Table 4.10) with the exception of PCBs. Aroclor 1016 was initially detected in one groundwater sample at a concentration of 1.6 μg/L, collected from Facility well GW-54S. However, this well was subsequently resampled for PCBs, and PCBs were not detected. Also, PCBs were not detected in any test pit samples (see Section 6.3), surface soil samples (see Section 4.4.2), or subsurface soil samples (see Section 6.4.3). Therefore, it was determined not to include PCB analyses on the SSPL.

These data have not been taken into account in the discussion which follows of groundwater chemistry at the Site or in the risk assessment. The more complete data base set generated during Round 1 and 2 groundwater sampling (see Section 6.5.3) will be used for these purposes. It is to be noted that these data are consistent with the Round 1 and 2 groundwater data.

6.5.3 Round 1 and 2 Groundwater Data

A summary of detected Round 1 and 2 groundwater parameters is presented in Appendix L, Tab 11.

Based on these data, a groundwater contaminant plume was delineated which occupies a large portion of the center of the Facility, extends to the east boundary of the Facility, and extends to just past Highway 38 (Main Street) west of the Facility. A smaller portion of the plume extends to the southwest of the Facility. The extent of the plume is closely tied to the centers of the buried bedrock valleys (see Section 5.3) and occurs in a stratified nature hugging the bedrock surface along the centers of the bedrock valleys.

For the purposes of this section, inorganic and organic chemistry will be discussed in individual Sections 6.5.4 and 6.5.5, respectively. Following these discussions, a general discussion of groundwater contaminant source and fate and transport follows in Section 6.5.6.

6.5.4 Inorganic Parameters

Upon review of the extensive data base generated during the CSA, four inorganic "indicator" parameters were chosen for concentration plots for the purpose of illustrating contaminant distribution within the aquifer system. These parameters are: ammonia, chloride, chromium, and sulphate. All four parameters are distributed throughout the plume. In addition, pH values were plotted and show a strong correlation to the distribution of the indicator parameters within the groundwater system. These concentration plots, made of both the shallow portion and deep portion of the aquifer, are presented on Plans 20 through 29, enclosed.

As the plans show, the deep portion of the aquifer has been impacted. The source of the plume appears to be the central portion of the Facility. Based on information provided by Olin, this location corresponds to early aerial photographs that show two pits to the south of Building C and to the southeast of Lake Poly. It is also consistent with later aerial photographs showing the new warehouses, where the two previous pits had been, with the new acid pits and Lake Poly as shown on Figure 2.4. Stepan built the water treatment plant and lined lagoons in 1970. This plant discharged treated wastewater through the property until 1970 when the MDC sewer line was completed in 1972. After purchasing the Facility in 1980, Olin relined Lagoon I in 1981 and Lagoon II in 1983.

The data also show that in the shallow portion of the aquifer only the central portion of the Facility is impacted. Discussions of the extent of the four parameters in the deep and shallow portions of the aquifer are provided in the following subsections.

6.5.4.1 Deep Portion of Aquifer

Chromium (Plan 20)

The distribution and extent of total chromium in the aquifer is consistent with the other indicator parameters. The highest concentration of chromium detected (3,600 mg/L) occurs just to the west of the Facility at well GW-42D. Further to the west, chromium was detected at wells GW-59D and GW-44D. Chromium concentrations drop off steeply around both the sides and front of the plume to the west. In the east central portion of the Facility the chromium concentrations also drop off quickly and do not extend as far as the East Ditch. Chromium was not detected in the southwest portion of the plume. Of the four indicator parameters, chromium shows the strongest affiliation with the low pH groundwater.

Based on information provided by Olin, this is consistent with the waste disposal from the Kempore process as it was operated between 1956 to 1967. During this time sodium dichromate was used in the process. The waste stream would contain, in addition to other constituents, chromium sulphate and sulphuric acid. This is consistent with the plume of low pH from the sulphuric acid and the chromium from the chromium sulphate. In 1967, the process was changed to use sodium chlorate instead of sodium dichromate. With the use of sodium chlorate, the waste stream would contain sodium chloride and sodium sulphate instead of chromium sulphate in addition to other constituents and sulphuric acid.

Chemical speciation was conducted in selected wells to determine the ratio of total chromium to hexavalent chromium (Cr VI) within the groundwater flow system. A ratio of approximately 10 percent Cr VI to total chromium was consistently observed.

Sulphate (Plan 22)

The distribution and extent of sulphate in the aquifer is consistent with the other three indicator parameters with the highest concentrations seen on the west side of the Facility. Concentrations as high as 87,000 mg/L were detected at well GW-30DR. The wells which define the west edge of the plume are wells GW-59D, GW-70D, and GW-58D and delineate the 1,000 mg/L contour.

Elevated sulphate concentrations extend to the east side of the Facility in the deep portion of the aquifer as observed in well GW-50D. The eastern extent of sulphate in the aquifer is defined by the East Ditch. It is believed that the East Ditch serves as a regional discharge point for groundwater. This is supported by the fact that well GW-48D, installed east of the East Ditch, immediately across from the Plant B and well GW-74D installed east of the East Ditch in the East Bedrock Valley, immediately downgradient of the Site, did not detect any Facility-related organic compounds or any Facility-related inorganic compounds above background.

To the southwest of the Facility, sulphate was detected in well GW-40D at a maximum concentration of 1,400 mg/L. The southwestern extent of sulphate in the aquifer is believed to be limited to the vicinity of the southwest corner of the Facility, as shown. This is supported by the fact that well GW-75D, installed in the Southwest Bedrock Valley, immediately downgradient of GW-40D, detected sulphate at a level (50 mg/L) similar to background.

Chloride (Plan 24)

The distribution and extent of chloride in the aquifer is consistent with the other indicator parameters. The highest concentrations of chloride are observed on and just to the west of the Facility in the deep portion of the aquifer. To the west, the 1,000 mg/L chloride concentration contour extends to wells GW-59D, GW-70D and GW-44D. Slightly elevated chloride concentrations are observed in wells GW-58D (730 mg/L), GW-67D (280 mg/L), GW-61D (160 mg/L) and GW-64D (110 mg/L) which extend west to and across the Maple Meadow Brook wetland. As shown, the concentrations decrease with distance from the plume.

Along the east side of the Facility, elevated chloride extends to the Facility boundary at levels approaching 250 mg/L. Similar to sulphate, the eastern extent of elevated chloride is defined by the East Ditch. Again, it is believed that the East Ditch serves as a regional discharge point for groundwater. This is supported by the fact that well GW-74D installed east of the East Ditch in the East Bedrock Valley, immediately downgradient of the Site, detected chloride at a level (71 mg/L) similar to background levels.

To the southwest of the Facility, elevated chloride was detected in well GW-40D at a maximum concentration of 340 mg/L. The extent of elevated chloride to the southwest is believed to be limited to the vicinity of the southwest corner of the Facility, as shown. This is supported by the fact that well GW-75D, installed in the Southwest Bedrock Valley, immediately downgradient of GW-40D, detected chloride at a level (64 mg/L) similar to background levels.

Ammonia (Plan 26)

The distribution and extent of Ammonia in the aquifer is consistent with the other indicator parameters. The highest concentrations of Ammonia are observed on and just to the west of the Facility in the deep portion of the aquifer. Concentrations as high as 12,000 mg/L were detected at well GW-42D. To the west, the 1,000 mg/L Ammonia concentration contour extends to wells GW-45D and GW-59D.

Along the east side of the Facility, elevated Ammonia levels extend to the Facility boundary (1,000 mg/L), but drop off sharply prior to the East Ditch (<400 mg/L).

To the southwest of the Facility, elevated Ammonia was detected in well GW-40D at a maximum concentration of 520 mg/L. Similar to sulphate and chloride, the extent of elevated Ammonia to the southwest is believed to be limited to the vicinity of the southwest corner of the Facility, as shown. This is supported by the fact that well GW-75D in the Southwest Bedrock Valley, immediately downgradient of GW-40D, detected Ammonia at a level (37 mg/L) similar to background levels.

Other Inorganic Parameters (Appendix L, Tab 11)

Several other inorganic parameters are elevated above background levels. These parameters include: aluminum, calcium, magnesium, potassium and sodium. In general, the distribution of these parameters in the aquifer closely resembles the distribution of the four indicator parameters discussed above.

Summary

Based on the Round 1 and 2 groundwater data, the plume is seen to emanate from the central portion of the Facility to just beyond Highway 38 (Main Street) to the west, edges just off the Facility boundary to the East Ditch and edges just off the southwest of the Facility in the vicinity of the Sulphate Landfill area.

The plume has been delineated vertically with geophysical data showing the contaminants are stratified along the bottom of the aquifer. The plume is approximately 20 feet thick near wells GW-36 and GW-42D. The plume thins to the west and is approximately eight feet thick at GW-58D approximately 1,700 feet west of the Facility. Plan 30, enclosed, shows the areal extent of the plume and Plan 31, enclosed, shows two cross-sections through the plume which depict the vertical distribution of the contaminant plume based on chemical and EM geophysical data.

6.5.4.2 Shallow Portion of Aquifer

The impact of inorganic contaminants on the shallow portion of the aquifer is limited to the immediate Facility area. As Plans 21, 23, 25 and 27 illustrate, elevated levels of the four indicator parameters are observed in the center of the Facility extending to just past the Facility boundary to the west, and to the Facility boundary on the east. The highest levels of contaminants are seen in the area of the former pits/lagoons.

Based on information provided by Olin, this is consistent with the waste disposal from the Kempore process as it was operated between 1956 to 1967. During this time sodium dichromate was used in the process. The waste stream would contain, in addition to other constituents, chromium sulphate and sulphuric acid. This is consistent with the plume of low pH from the sulphuric acid and the chromium from the chromium sulphate. In 1967, the process was changed to use sodium chlorate instead of sodium dichromate. With the use of sodium chlorate, the waste stream would contain sodium chloride and sodium sulphate instead of chromium sulphate in addition to other constituents and sulphuric acid.

6.5.5 Organic Parameters

Organic compounds were detected during the CSA investigation in two primary areas of the Facility; the Plant B area, and the area around the center of the Facility near the former unlined pits/lagoons and Lake Poly. Sporadic and infrequent organic compounds were detected in deep wells to the west of the Facility. Plans 16 through 19 present groundwater data for selected organic parameters (see Section 6.2).

As shown on the Plans, the area around Plant B has been impacted by low levels of VOCs and high levels of the Bis(2)ethylhexyl Phthalate (B2EHP) and N-Nitrosodiphenylamine (NNDPA). The area affected is concentrated around the present groundwater interceptor well system (see Section 2.3). In the interceptor wells, installed to stop oil from seeping into the East Ditch, a floating oil layer is removed periodically and sent off Site for incineration due to the high percent concentration of the dioctylphthalate present in the oil.

Based on information provided by Olin, this is consistent with historic operations in that area. Behind Plant B were six (6) 15,000 gallon storage tanks. Among the materials stored were dioctylphthalate, bis(2-ethylhexyl)phthalate and "Process Oil". An aerial photograph clearly shows a stream/ditch leaving the Plant B building and going to the East Ditch.

After Olin purchased the Facility a concrete floor and dike was constructed around the storage tank area. When the construction was in progress, due to contamination, soil removed from under and around these tanks was disposed of off Site in a secure landfill.

In the central portion of the Facility, several VOCs were detected in both the shallow and deep portions of the aquifer. West of the Facility, VOCs were detected primarily in the deep portion of the aquifer with no apparent consistent distribution. The principal detected VOCs include *Acetone, Toluene,* 244TM1P, 244TM2P and Bromoform. SVOCs were also detected in this area and to the west of the Facility. The principal detected SVOCs included phenolic compounds and NNDPA, which was detected primarily on the Facility only.

Sporadic and infrequent low levels of pesticides (<0.3 µg/L) were detected in various wells around the Facility.

6.5.6 Groundwater Chemical Source Areas

6.5.6.1 General

Section 2.2 of this report outlines the process and waste disposal history at the Facility from 1953 to 1986 when the plant closed. As discussed in Section 2.2, wastes from various processes entered unlined pits located near the center of the Facility from approximately 1953 to 1970. Other wastes including yard and process spills and process drains which were directed into an on-Site drainage system which discharged into unlined Lake Poly located along the west side of the Facility. A summary of the raw materials, products and waste by-products included in these waste streams is provided in Table 2.1.

Based on information provided by Olin, in 1969 Stepan entered into a Consent Order to install a waste treatment plant to neutralize the acidic waste and lined lagoons. The plant was completed in 1970. The treated wastewater was discharged through the property until 1972 when the Metropolitan District Commission sewer line was completed.

After Olin purchased the Facility, Lagoon I was relined in 1981 and Lagoon II in 1983.

6.5.6.2 Inorganic Parameters

Based on the available knowledge of chemicals which were directed into the unlined pits and Lake Poly and a review of aerial photographs, these areas are considered to be the primary source of the inorganic plume associated with the Facility. Though it is over 20 years since discharge into the pits ceased, elevated concentrations of the Facility-related waste compounds in groundwater correlate to the position of these areas. In addition, soil samples collected from borings completed in the Lake Poly area exhibited the highest levels of chromium concentrations in the subsurface soils.

The majority of the inorganic contamination appears to emanate from the central area of the Facility. To some extent, the Sulphate Landfill to the southwest of the Facility, may be contributing to sulphate, chloride and ammonia concentrations in this area.

6.5.6.3 Organic Parameters

As discussed in Section 6.5.5, organic contaminants were identified in two primary areas at the Facility; the Plant B area, and the area around the central portion of the Facility. Also of note are the elevated levels of organic compounds at well GW-49 located off the Facility to the east. Following is a discussion of the potential sources of these contaminants in the aquifer.

Organic contamination in the Plant B area has been attributed to the spills, leaks and release of oily compounds associated with manufacturing processes and storage tanks in this area. An unknown amount of oil was released over the course of operations at Plant B. Based on information provided by Olin, in employee interviews, this area seemed to be mentioned most frequently concerning spills, leaks and discharges that occurred in the past. In aerial photographs a stream can be seen leaving the Plant B building and proceeding to the East Ditch.

When Olin installed the concrete floor and dike walls around the Plant B storage tanks, a large amount of contaminated soil was disposed of off Site at an approved disposal facility.

To clean up the banks of the East Ditch behind the Storage Tanks in the Plant B area, in 1982 Olin removed a portion of the bank and replaced it with clean fill. Currently, the oil is being prevented from impacting the East Ditch by a pump and treat system that is discharged through a NPDES permitted outfall (see Section 2.3).

The organic contaminants found in the groundwater in the central portion of the Facility are most likely attributable to three sources; the discharge of yard spills, process drains and oily wastes from the Opex process to Lake Poly, the disposal of organic wastes to the pits, and the disposal of drums containing organic compounds beneath the ground surface.

No apparent correlation can be made between the Facility and the organic compounds detected in well GW-49. Also, as discussed in Section 6.7 (Sediments), elevated levels of VOCs, which were not detected at the Facility, are detected in the sediments downstream of this location.

6.5.7 Groundwater Contaminant Transport

To assess contaminant transport, hydrogeologic conditions and chemical data must be integrated. Following is a discussion of contaminant transport in the groundwater. Appendix K presents a detailed discussion on the fate and transport of Site-specific contaminants in the environment.

6.5.7.1 Inorganic Parameters

The extent of the plume based on the Round 1 and 2 groundwater data has been discussed in Sections 6.5.4 and 6.5.5. The plume extends to the west just west of Highway 38 (Main Street), edges off the Facility boundary to the East Ditch, and edges off the Facility to the southwest in the vicinity of the Sulphate Landfill. Vertically, the plume is stratified occupying the bottom of the aquifer ranging in thickness from approximately 20 feet on the east at well GW-42D and thins to approximately eight feet at well GW-58D, approximately 1,700 feet west of the Facility. It has been interpreted that the plume is stratified due to the density difference between the heavier waste discharged and natural groundwater. Table 6.2 provides a summary of specific gravity analyses performed on selected wells at the Site. A review of these data shows that the shallow groundwater system exhibits a specific gravity of 1.005 to 1.015. The deep wells immediately adjacent to the west side of the Facility exhibit a specific gravity of approximately 1.1. Further to the west the specific gravity in the deep well GW-45D decreased to 1.06. Near the edge of the plume, the deep wells exhibit specific gravity around 1.005, similar to that measured in the shallow monitoring wells at the Site.

A discussion of the groundwater flow conditions was provided in Section 5.4. In summary, a zone of regional groundwater divide was identified in the area west and north of the Facility. Groundwater flow west of this divide is towards the northwest into the Ipswich River hydrologic basin and groundwater flow east of the divide is towards the southeast and Aberjona River hydrologic basin. Shallow groundwater at the Facility discharges into the ditch complex surrounding it.

Plume Migration

As is apparent, the dense plume has migrated in a direction opposite of the natural groundwater flow system to the immediate west of the Facility. The potential reason for this is the wastewater, being more dense than the natural groundwater, settled through the aquifer, flowing by force of gravity along the slope of the bottom of the aquifer (bedrock valley surface). The relatively narrow bedrock channel which runs just below the central portion of the Facility, provided a route for the migration of the plume to the west. The opposing force of natural groundwater flow to the southeast is rather weak in the area west of the Facility as the horizontal hydraulic gradients are very low.

It is believed that as long as the dense acidic wastewater was being discharged at relatively high volumes, the driving force of hydraulic gradients caused by gravity was predominant in influencing the flow of the contaminants to the west, against the natural groundwater flow direction. In effect, over time, the plume was being "pushed" to the west by the recharge of higher density wastewater into the aquifer.

Factors Affecting Plume Migration

Three factors are believed to have had the major influence over dense contaminant migration in the aquifer: the slope of the bedrock surface; the hydraulic forces generated from recharge of the wastewater; and the dilution effects at the plume edge which control pH. Following is a discussion of these factors.

Bedrock Slope

The slope of the bedrock surface is steeper in the area just west of the Facility, and gradually flattens out west of Highway 38 (Main Street). It is believed that the flattening out of the slope of the bottom of the aquifer subsequently results in decreased movement of the plume via gravity.

Wastewater Discharge Effects on Hydraulic Head

For approximately 17 years, acidic wastewater was recharged into the aquifer, creating an artificial hydraulic head which increased the migration rate of the plume. When the discharge of wastewater ceased, the artificial hydraulic head was eliminated, resulting in lower migration rates of contaminants. It is believed that the effects of the natural groundwater flow system has minimal effect in retarding the movement of the dense portion of the plume.

Combined Effects of Slope and Hydraulic Head

The volume of the dense portion of the plume is now fixed, and when considered with the factor of decreased slope of the bedrock surface with distance from the Site, the hydraulic gradients caused by gravity as a driving mechanism for the plume will decrease over time. As the hydraulic gradients decrease, it is believed that the dense portion of the plume has reached a "physical" equilibrium within the aquifer flow system or is moving very slowly.

Effects of Dilution on pH and Plume Mobility

The concentrations of chromium in the plume is closely tied to the pH levels, with the solubility of the chromium being greatly increased with increasing acidic conditions. The chromium concentration plans (Plans 20 and 21) illustrate that the "concentration gradients" of the plume are steep around all sides. This is believed to be a result of the rapid rise in pH from the center portion of the plume to the plume edges. The increase in pH due to dilution has greatly decreased the solubility of the chromium on the plume edges. It is believed that the effects of the natural groundwater diluting the main portion of the dense plume is a significant factor in restricting the plume migration. Over time, the plume will reach chemical equilibrium within the aquifer system.

The redox potential of the groundwater may also influence the mobility of the inorganic parameters (chromium, sulphate and ammonia). Changes in the ionic state of these parameters will affect the solubility and mobility of the parameters in the aquifer.

Conditions Beyond the Dense Portion of the Plume

In well GW-62BR, which is screened in the bedrock below the sand and gravel aquifer, elevated levels of three of the four indicator parameters are noted. Concentrations of sulphate (160 mg/L), chloride (110 mg/L) and ammonia (100 mg/L) have been detected in well GW-64D. This well is located west of the dense portion of the plume in the vicinity of the Butters Row Pumping Station. It is believed that the elevated levels above background for these parameters in this well is the result of the "dissolution" and migration in the groundwater flow system away from the main, dense portion of the plume. Since the pH has increased greatly from inside the main body of the plume, the solubilities of these compounds within the aquifer has decreased orders of magnitude. It is believed that the migration of these compounds west of the main plume body is a function of the natural groundwater flow system, as opposed to the gravity driven flow mechanism proposed for the dense portion of the plume. Those parameters (such as chromium) which are more dependent on low pH for increased solubility and hence mobility within the groundwater system, should not migrate beyond the dense, low pH portion of the plume.

Contaminant Flow Into the Site Ditches

A portion of the plume is at present discharging to the ditch complex surrounding the Facility as evidenced by the observed flocculant material and chemical analysis of surface water and sediment. This discharge is most likely from the shallow portion of the aquifer on the west side of the Facility. The chemical concentration plots of the shallow aquifer also indicate contaminant flow to, but not beyond, the south and east ditches. Groundwater elevation data show flow towards the ditch as well.

6.5.7.2 Organic Parameters

Organic compounds in groundwater have been detected in two principle locations as discussed in Section 6.5.4. The Plant B area organic contaminants historically were observed discharging to the east ditch; however, the area is currently under control by an interceptor well system, with control of the oil seeps being achieved. Therefore, no discussion of organic contaminant transport will ensue for this area.

In the central portion of the Facility, and to the west of the Facility, organic compounds are detected in a random distribution pattern and no organic "plume" delineation was attempted. It is likely that the scattered nature of the disposal areas, combined with the irregular timing of waste releases has resulted in this random pattern. Based on the surface water data, at least a portion of the organic contaminants are discharging to the ditches.

As most of the organic contaminants were detected only in deep wells to the west of the Facility, it is likely that these compounds were transported with the dense inorganic plume via gravity flow to the west. Several of the compounds which are detected on the Facility are detected only sporadically, or are not detected at all off the Facility. Although no detailed study of organic compound fate was conducted, it is likely that many of the SVOCs have adsorbed to the aquifer materials.

6.6 SURFACE WATER CHEMISTRY

6.6.1 General

As discussed in Section 4.15.2, an extensive surface water sampling program for chemical analyses was conducted as part of the CSA Phase II field activities. As summarized in Section 6.1, two rounds of surface water samples, were collected and analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (first round consisted of 22 samples and second round consisted of 36 samples including QA/QC requirements). During the first round, 2 samples were also collected for hexavalent chromium analysis and during the second round 6 samples were collected for hexavalent chromium analysis (see Tables 4.12 and 4.13). Plan 7, enclosed, presents surface water sampling locations.

A summary of the following data is presented in Appendix L:

- Tab 13 Summary of Detected Round 1 and 2 Surface Water Data;
- Tab 14 Average Detected Concentrations for Round 1 and 2 Surface Water Data;

- Tab 23 Summary of Surface Water Data Previous to Round 1; and
- Tab 24 Summary of Round 1 and 2 Surface Water Data.

Plan 32, enclosed, presents a summary of selected parameters (see Section 6.2) for Rounds 1 and 2 surface water samples. The following subsections present a summary of the analytical data for surface water.

6.6.2 <u>Surface Water Characteristics</u>

VOCs

A review of the VOC data presented on Plan 32, enclosed and Appendix L, Tab 13 indicates sporadic and infrequent detection of VOCs in the surface water with the exception of 244TM1P and 244TM2P. 244TM1P was detected at 16 of 30 surface water sampling locations and 244TM2P was detected at 13 of 30 surface water sampling locations. The maximum detected concentration of 244TM1P was 200 µg/L with an average detected concentration of approximately 17 µg/L and the maximum detected concentration of 244TM2P was 81 µg/L with an average detected concentration of approximately 9 µg/L. The maximum concentrations of both 244TM1P and 244TM2P were detected at location SW-15, the furthest most upstream sample in the West Ditch bordering the Facility. Samples from the West Ditch also exhibited the highest detectable levels of Acetone at 93 µg/L. As discussed in Section 5.4.3.2, shallow groundwater flow along the west central portion of the Site discharges to the West Ditch. This area is downgradient and adjacent to the former lagoons (SWMU No. 10), acid pits (SWMU No. 15), former Lake Poly (SWMU No. 14) and the two pits under the existing warehouses. As discussed in Section 6.4, the maximum subsurface soil concentrations for 244TM1P 244TM2P, and Acetone were all detected in the area of former Lake Poly, upgradient to the West Ditch.

In the northern branch of the South Ditch, 244TM1P and 244TM2P, were detected at all locations. However, in the southern branch of the South Ditch, neither 244TM1P and 244TM2P were detected in any sample.

In the East Ditch bordering the Facility, the following halogenated VOCs were detected in the surface water samples: 1,1,1-Trichloroethane(111TCE), 1,1-Dichloroethene (11DCLE), Chloroethane (C2H5CL), Methylene Chloride (C2CL2), and Trichloroethene (TRCLE). The highest concentrations of each of these parameters were typically detected at sample locations SW-1, SW-29 and SW-30. As shown on Plan 32, enclosed, SW-1, SW-29 and SW-30 are located in the East Ditch upstream of the Facility. This suggests that the source of the halogenated VOCs is located upstream of the Facility. This is supported by the fact that the halogenated VOCs were not typically detected in Facility test pit samples, surface and subsurface soils or Facility groundwater.

244TM1P and 244TM2P were also detected in the East Ditch, specifically at locations SW-2 and SW-3. These two locations are situated immediately downstream of the Plant B area (SWMU No. 13 and No. 23) and the black area east of Plant D (SWMU No. 26) where surface soils *were previously removed, respectively.* 244TM1P *and* 244TM2P *were also* detected in the East Ditch at locations SW-25, SW-26 and SW-27. The furthest downstream sample in the East Ditch, SW-28 did not detect 244TM1P and 244TM2P. Toluene and 2-Hexanone (MNBK) were also detected in the East Ditch, specifically at locations SW-29 and SW-30. The detected concentrations for Toluene at SW-29 and SW-30 were 140 µg/L and 240 µg/L, respectively. The detected concentrations of 2-Hexanone (MNBK) at SW-29 and SW-30 were 33 µg/L and 39 µg/L, respectively. These locations are situated immediately upstream of the Facility. This suggests that the source for these contaminants is located upstream of the Facility. Further downstream, the detected concentration of Toluene at SW-23, SW-24, SW-25, SW-26, SW-27 and SW-28 was 42 µg/L, 76 µg/L, 70 µg/L, 56 µg/L, 26 µg/L, and 5 µg/L, respectively. The two samples immediately upstream of location SW-23, locations SW-4 and SW-5, did not detect Toluene. As discussed in Section 6.5, the groundwater at monitoring well GW-49 exhibited Toluene at a concentration of 12,000 μg/L. The Toluene at well GW-49 is not considered to be associated with the Facility. As shown on Plan 3, enclosed, well GW-49 is located east of the Facility, downstream of sample location SW-5 but upstream of sample locations SW-23, SW-24, SW-25, SW-26, SW-27 and SW-28. This strongly suggests that the source of Toluene at locations SW-23 through SW-28 is associated with a source located east of the Facility.

SVOCs

A review of the SVOC data presented on Plan 32, enclosed, and Appendix L, Tab 13 indicate sporadic and infrequent detection of SVOCs in the surface water with the exception of Bis(2-ethylhexyl)Phthalate (B2EHP), N-Nitrosodiphenylamine (NNDPA) and Phenol.

B2EHP was detected at 21 of 30 surface water sampling locations. The maximum concentrations of B2EHP were detected in the northern branch of the South Ditch at location SW-8 (48 μg/L) and in the East Ditch at location SW-26 (74 μg/L). All other detected concentrations of B2EHP were below 14J μg/L.

NNDPA was detected at 9 of 30 surface water sampling locations. Similar to 244TM1P and 244TM2P, the maximum concentration of NNDPA was detected in the West Ditch at upstream location SW-15. As discussed above, the West Ditch receives shallow groundwater discharge from the Facility. As discussed in Section 6.4, the maximum subsurface soil concentration for NNDPA is in the area of former Lake Poly (SWMU No. 14).

Phenol was detected at 6 of 30 surface water sampling locations, with five of the six detections occurring in the West Ditch. The maximum concentration of phenol detected in the surface water was 3J μg/L.

At location SW-15 (West Ditch, upstream sample) low levels of various PAHs were also detected at concentrations ranging from 3J µg/L to 33 µg/L. This is the only surface water location which detected PAHs.

Pesticides

With the exception of one detected concentration of Endrin Aldehyde (ENDRN) at SW-5 (East Ditch) at a concentration of 0.11 µg/L, location SW-15 was the only location which exhibited detected concentrations of pesticides. At location SW-15 (West Ditch, upstream sample), six pesticides were detected with a maximum concentration of 0.49 µg/L.

Inorganics

A review of the inorganics surface water data presented on Plan 32, enclosed, and Appendix L, Tab 13, indicates that the following inorganic parameters were elevated above acute and/or chronic U.S. EPA Ambient Water Quality Criteria (AWQC) for protection of freshwater aquatic life:

	Freshwater AWQC (µg/L) [a]		Max. Detected Concentration (µg/L)		
Compound	*Acute*	*Chronic*	*West Ditch*	*South Ditch*	*East Ditch*
Aluminum [b]	75	87	59,000	21,000	3,500
Ammonia [b]	23,000	2,100	120,000	110,000	34,000
Calcium	--	--	180,000	140,000	57,000
Chloride	860,000	230,000	590,000	190,000	210,000
Chromium VI	16	11	400J	74J	270
Chromium III [c][d]	1,700	210	12,000	1,700	410
Copper [d]	18	12	120	ND	ND
Iron	--	*1,000*	*26,000*	*72,000*	*5,400*
Sodium	--	--	290,000	200,000	120,000
Sulphate	--	--	3,000,000	590,000	270,000
Zinc [d]	120	110	190	96	200

Notes:

(a) All values are from 1980, 1984, or 1988 U.S. EPA Ambient Water Quality Criteria (AWQC) documents.
(b) Criteria are pH dependent and/or temperature dependent. Aluminum assumed at pH 6 to pH 9, and total ammonia assumed at pH 7.0, and 20 degrees Celsius.
(c) Surface water analytical data reported as total chromium.
(d) Hardness dependent criteria (assumed hardness of 100 mg/L, as $CaCO_3$).

As indicated by the above data, the maximum concentration of all the inorganic parameters, except zinc, decrease as one moves downstream from the West Ditch, to the South Ditch, to the East Ditch.

The highest levels of inorganic parameters were typically detected at SW-16 in the West Ditch. Field observations conducted during sampling noted considerable discoloration of the sediment in the area around SW-16. Heavy red and white material was noted on the West Ditch bottom, which appeared to be a flocculant material. Downgradient from this location, levels of inorganic parameters stabilize and in some cases, drop off.

No significantly elevated levels of inorganic parameters were detected in the ditch above the junction of the South Ditch complex. Field observations conducted during sampling noted a black oily sheen on sediments in the South Ditch sampling locations. Below the junction, levels of inorganic parameters increase at low levels, due to the input from the West Ditch.

6.6.3 Surface Water Characterization Summary

The analytical data collected during the surface water sampling program indicated the following compounds were detected in surface waters at the Facility:

VOCs: 244TM1P, 244TM2P, Toluene, 2-Hexanone and Acetone;

SVOCs:	Bis(2-ethylhexyl)Phthalate (B2EHP), N-Nitrosodiphenylamine (NNDPA), and Phenol; and
Inorganics:	Aluminum, Ammonia, Calcium, Chloride, Chromium (III and VI), Copper, Iron, Sodium, Sulphate and Zinc.

The highest concentrations of 244TM1P, 244TM2P, Acetone, NNDPA, Phenol and all the inorganics except for iron, were detected in the West Ditch. The West Ditch receives groundwater discharge from the Facility. The highest concentrations of B2EHP and iron were detected in the South Ditch. The South Ditch also receives groundwater discharge from the Facility. It is also important to note that the only significantly elevated levels of iron detected in either the test pit samples or soil samples collected at the Facility were detected in the drum sample from test pit 21 (near the South Ditch) and in the hand auger sample collected from SWMU No. 33 (also near the South Ditch at GW-55 well nest).

In addition to the above noted VOCs detected at the Facility, halogenated VOCs: 111TCE, 111DCLE, C2H5CL, C2CL2 and TRCLE were detected in the upstream portions of the East Ditch and are probably attributed to a source located upstream of the Facility. Also, the concentrations of Toluene at the furthest upstream samples in the East Ditch is probably attributable to a source located upstream of the Facility.

244TM1P, 244TM2P, Toluene, 2-Hexanone and Acetone are highly water soluble and once in the surface water, these compounds will rapidly volatilize as indicated by their moderate to high Henry's Law Constants. Adsorption and sedimentation are not expected to be a predominant removal process.

However, for B2EHP, NNDPA and Phenol, volatilization will not be significant but adsorption and sedimentation will be predominant. K_{OC} values for B2EHP and NNDPA indicate very high adsorption potential and thus, minimal mobility in the surface water. However, for Phenol, a low

K_{OC} value of 129 indicates low adsorption potential and thus, high tendencies to partition to the water.

All inorganics exhibit high solubilities and will, therefore, show high potential for partitioning to surface water.

Appendix K presents a detailed discussion pertaining to fate and transport of the above compounds in surface water.

6.7 SEDIMENT CHEMISTRY

6.7.1 General

As discussed in Section 4.15.3, an extensive sediment sampling program for chemical analyses was conducted as part of the CSA Phase II field activities. As summarized in Section 6.1, two rounds of sediment samples, were collected and analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (first round consisted of 25 samples and second round consisted of 35 samples including QA/QC requirements). During the first round, 2 samples were also collected for hexavalent chromium analysis and during the second round, 8 samples were collected for hexavalent chromium analysis (see Tables 4.14 and 4.15). Plan 7, enclosed, presents sediment sampling locations.

A summary of the following data is presented in Appendix L:

- Tab 9 Summary of Detected Round 1 and 2 Sediment Data;
- Tab 10 Average Detected Concentrations for Round 1 and 2 Sediment Data;
- Tab 18 Summary of Sediment Data Previous to Round 1; and
- Tab 19 Summary of Round 1 and 2 Sediment Data.

Plan 33, enclosed, presents a summary of selected parameters (see Section 6.2) for Rounds 1 and 2 sediment samples. The following subsections present a summary of the analytical data for sediments.

6.7.2 Sediment Characteristics

VOCs

A review of the VOC data presented on Plan 33, enclosed and Appendix L, Tab 9 indicates sporadic and infrequent detection of VOCs in the sediments with the exception of 244TM1P, 244TM2P, Acetone and Toluene. 244TM1P was detected at 23 of 29 sediment sampling locations and 244TM2P was detected at 20 of 29 sediment sample locations. Acetone was detected in 18 of 29 sediment locations and Toluene was detected in 14 of 29 sediment locations. It should be noted that Acetone was only detected in the first round sediment samples and Toluene was mainly detected in only the second round sediment samples.

The maximum detected concentration of 244TM1P was 28 mg/kg with an average detected concentration of approximately 1.6 mg/kg and the maximum detected concentration of 244TM2P was 9.4 mg/kg with an average detected concentration of approximately 0.62 mg/kg. The maximum concentrations of both 244TM1P and 244TM2P were detected at location SW-13 in the West Ditch bordering the Facility. The samples from the West Ditch also exhibited the highest detectable levels of Toluene at a concentration of 1.1J mg/kg. In addition, the West Ditch samples also exhibited frequent detection of Bromoform (CHBR3) (0.14 mg/kg), Dibromochloromethane (DBRCLM) (0.035 mg/kg) and Ethylbenzene (ETC6H5) (0.71 mg/kg). These compounds were not detected in other ditch sediments.

As discussed in Section 6.6.2, shallow groundwater flow along the west central portion of the Site discharges to the West Ditch. This area is downgradient and adjacent to the former lagoons (SWMU No. 10), acid pits (SWMU No. 15), former Lake Poly (SWMU No. 14), and the two pits under the existing warehouses. As discussed in Section 6.4, the maximum subsurface soil concentrations for 244TM1P, 244TM2P and Toluene were all detected in the area of former Lake Poly, upgradient to the West Ditch. Toluene was also detected in drum samples collected from test pits 6, 7 and 8 (SWMU No. 19). General field observations made during the CSA noted an oily product in the sediment of the West Ditch.

In the northern branch of the South Ditch, 244TM1P and 244TM2P were detected at all locations. The maximum concentration detected in the South Ditch for 244TM1P was 4.7J mg/kg and for 244TM2P was 1.5J mg/kg. However, in the southern branch of the South Ditch, only trace amounts of 244TM1P (0.004J mg/kg) were detected in two samples. The maximum concentration of Acetone was detected at location SW-8 in the South Ditch at a concentration of 1.7 mg/kg. This location is adjacent to the central pond located on the Facility. A halogenated VOC, 11DCLE was also detected at three locations in the South Ditch with a maximum concentration at location SW-8 of 0.034J mg/kg. 2-Butanone (MEK) and 2-Hexanone (MNBK) were also detected in two sediment samples, locations SW-8 and SW-9, at maximum concentrations of 0.074J mg/kg and 0.036 mg/kg, respectively. Both of these sample locations are adjacent to the central pond at the Facility. General field observations made during the CSA noted an oily material in the sediments between the junction of the West Ditch and South Ditch and the central pond.

Based on information provided by Olin, the oily material is probably a waste from the OPEX process which took place in Plant A. Oil was used in the process to reduce the flammability of the product. Until about 1970, excess oil, spills and wash downs would be discharged to Lake Poly which emptied into the West Ditch. The drainage lines and Lake Poly are shown on Figure 2.3. In a 1969 report, for National Polychemicals Inc., an oily component was observed as a "Floating material from the Lake Poly sewer...". It should be noted that this oily material was observed in sediment samples taken from the ditches and was also evident in the south ditch "central pond".

The waste treatment system was installed by Stepan in 1970 and included an oil removal step before treatment.

244TM1P and 244TM2P were detected in most samples collected from the East Ditch at maximum concentrations of 0.2 mg/kg and 1.1 mg/kg, respectively at SW-25.

Trichloroethene (TRCLE) was detected in the surface sediments in the East Ditch at locations SW-4, SW-5, and SW-6 at maximum concentrations of 0.005J mg/kg, 0.05 mg/kg and 0.01 mg/kg, respectively. Further downstream TRCLE was detected at locations SW-23, SW-24, SW-25 and SW-27 at maximum concentrations of 0.15 mg/kg, 0.024J mg/kg, 0.029 mg/kg, and 0.02 mg/kg, respectively. TRCLE was detected in three upstream samples in the East Ditch at SW-2, SW-29 and SW-30 at a concentration of 0.002J mg/kg, 0.002J mg/kg and 0.018 mg/kg, respectively. The concentration in the upper portion of the East Ditch suggests that the source of TRCLE is associated with a source located upstream of the Facility.

SVOCs

A review of the SVOC data presented on Plan 33, enclosed, and Appendix L, Tab 9, indicates frequent detection of various PAHs, phthalate isomers and N-Nitrosodiphenylamine (NNDPA).

The PAHs detected in the sediments include:

Compound		*Max. Detected Concentration (mg/kg)* West Ditch	South Ditch	East Ditch
Acenaphthylene	(ANAPNE)	-	-	0.25J
Anthracene	(ANTC)	-	-	0.52J
Benzo(a)Anthracene	(BAANTR)	2.1J	0.095	1.7J
Benzo(a)Pyrene	(BAPYR)	0.6J	0.10	2.0
Benzo(b)Fluoranthene	(BBFANT)	1.2	0.18	4.4
Benzo(g,h,i)Perylene	(BGHIPY)	0.45J	0.083	2.1
Benzo(k)Fluoranthene	(BKFANT)	0.29J	-	1.4J
Chrysene	(CHRY)	0.73J	1.3J	3.4
Dibenzo(a,h)Anthracene	(DBAHA)	0.12	-	0.43
Dibenzofuran	(DBZFUR)	5.9J	-	0.22J
Fluoranthene	(FANT)	4.0	0.092	4.5
Indeno(1,2,3-cd)Pyrene	(ICDPYR)	0.56	13.0J	1.3
Naphthalene	(NAP)	2.2J	-	2.7
Phenanthrene	(PHANTR)	34.0	4.2J	1.9
Pyrene	(PYR)	9.1J	0.93J	3.5

As shown above, ten of the 15 PAHs detected in the sediments are at their highest concentrations in the East Ditch and three of the 15 PAHs detected in the sediments are at their highest concentrations in the West Ditch.

As discussed in Appendix K, PAHs are ubiquitous in the environment and are formed during the incomplete combustion of virtually all forms of organic materials. As noted above, the highest concentrations of 13 of the 15 PAHs were detected in either the West Ditch or the East Ditch. Both ditches run parallel to rail lines. It is presumed that at one time, the trains that used the rail system utilized coal as a fuel source. The levels of PAHs found in the Site samples parallel those for industrial and urban development. A comparison of the PAHs in the sediments to typical concentrations in urban soils (see Table K.5, Appendix K) shows that the PAHs detected in the sediments at the Site are within typical urban soil concentration ranges.

The phthalate isomers detected in the sediments include:

Compound		Max. Detected Concentration (mg/kg) West Ditch	South Ditch	East Ditch
Bis(2-ethylhexyl)Phthalate	(B2EHP)	200,000	60,000J	9,300
Butyl Benzylphthalate	(BBZP)	160J	17J	0.4J
Di-N-Butylphthalate	(DNBP)	1,400J	60	0.23
Di-N-Octylphthalate	(DNOP)	2.1	24J	10
Diethylphthalate	(DEP)	0.79J	-	-
Dimethylphthalate	(DMP)	0.18	0.53	-

B2EHP was detected at 28 of 29 locations sampled. Concentrations generally decreased from the West Ditch, to the South Ditch, to the East Ditch. The furthest downstream sample in the East Ditch (SW-27) exhibited a concentration of 80 mg/kg. BBZP, DNBP and DNOP were also frequently detected, however, were mostly limited to the West and South Ditches. DEP and DMP were sporadically and infrequently detected.

NNDPA was detected at 22 of 29 sediment sample locations. The maximum concentration of NNDPA was detected in the West Ditch at location SW-13 (6,200J mg/kg). In the South Ditch, NNDPA was detected at location SW-9 (adjacent to the central pond) at a maximum concentration of 720J mg/kg. The maximum concentration of NNDPA in the East Ditch was at location SW-23 at a concentration of 2.1 mg/kg. The concentration of NNDPA dropped off to 0.8 mg/kg at location SW-24 and to 0.29 mg/kg at SW-27, the furthest sample downstream. The data show the NNDPA is prevalent in the sediments and decreases from the West Ditch, to the South Ditch, to the East Ditch.

As discussed in previous sections, groundwater flow from the Facility discharges to all three ditch systems. The West Ditch is located the closest to the former lagoon areas (SWMU No. 9 and 10), the former acid pits (SWMU No. 15), the former Lake Poly (SWMU No. 14), and the buried waste drums (SWMU No. 19), and the pits located under the existing warehouses. The South Ditch also receives groundwater discharge from some of these areas. As discussed in Appendix K, phthalate isomers and NNDPA, due to their high K_{OC} values, will readily adsorb to suspended matter and sediments.

Pesticides

A review of the Pesticides data presented in Appendix L, Tab 9, shows that all pesticides were detected sporadically and infrequently. Endosulfan Sulphate (ESFSO4) and Endrin Aldehyde (ENDRNA) were the most frequently detected pesticides. ESFSO4 was detected at 6 of 30 sample locations at a maximum concentration of 0.24 mg/kg (SW-15) and ENDRNA was detected at 10 of 30 sample locations at a maximum concentration of 6.5 mg/kg (SW-3).

Inorganics

A comparison of the inorganic data presented on Plan 33, enclosed, and in Appendix L, Tab 9, to Site-specific background surface soil data presented in Appendix L, Tab 20, indicates that the following inorganic compounds in the sediment samples exhibited elevated concentrations above background for the Site:

	Max. Detected Concentration (mg/kg)		
Compound	***West Ditch***	***South Ditch***	***East Ditch***
Aluminum	150,000	13,000	60,000
Antimony	120	88	33
Ammonia	1,000	410	410
Calcium	910	1,900	9,900
Chloride	1,400	240	240
Chromium VI	300J	140J	33J
Chromium (total)	8,900	2,900	3,000
Iron	83,000	13,000	140,000
Mercury	0.96	1.2J	1.3
Sodium	1,600	500	560
Sulphate	6,000	3,200J	18,000
Zinc	110	78	1,100

All of the above listed inorganic parameters were present in sediments above Site-specific background levels across the Facility.

Parameter concentrations typically decrease from the West Ditch to the South Ditch and then remain relatively consistent in the East Ditch. The furthest downstream sample collected in the East Ditch (SW-27) shows a total chromium concentration at 1,900 mg/kg, a sulphate concentration of 4,300 mg/kg, an ammonia concentration of 370 mg/kg and a chloride concentration of 240 mg/kg. For inorganic parameters, antimony, iron and mercury the concentrations are relatively constant across the Site sediments.

6.7.3 Sediment Characterization Summary

The analytical data collected during the sediment sampling program indicated that the following major compounds were frequently detected in sediments at the Site:

VOCs:	244TM1P, 244TM2P, Toluene and Acetone;
SVOCs:	Bis(2-ethylhexyl)Phthalate (B2EHP), Butyl Benzylphthalate (BBZP), Di-N-Octylphthalate (DNOP), Di-N-Butylphthalate (DNBP) and N-Nitrosodiphenylamine (NNDPA); and
Inorganics:	Aluminum, Ammonia, Calcium, Chloride, Chromium (VI & total), Sodium and Sulphate.

The highest concentrations of all the above compounds were generally detected in the West Ditch and decreased across the Facility.

It is to be noted that VOCs including TRCLE, 12DCE, CLC6H5, TCLEE and C2H3CL were detected at maximum concentrations at location SW-23 in the East Ditch downstream of the Facility. Downstream locations SW-25 and SW-27 also exhibit elevated concentrations of the above

VOCs. These data suggest a source other than the Facility and are also supported by groundwater data from well GW-49D (see Section 6.5).

The atmospheric fate and transport mechanisms for 244TM1P and 244TM2P are characterized by a high vapor pressure of 77.5 mm Hg at 38°C. This indicates potentially significant volatility from sediment. There are no available data found regarding water solubility. Soil adsorption cannot be predicted due to the lack of available Koc values in literature (see Appendix K).

As discussed for test pit samples, the phthalate isomers, B2EHP, BBZP, DNBP, DNOP and NNDPA all exhibit high Koc values and will strongly adsorb to organic material in soils. Therefore, they have a very low potential for partitioning to the surface water and will be virtually immobile in the sediments. However, the migration of phthalate isomers and NNDPA may occur via sediment transport in surface water. The inorganic compounds ammonia, calcium, chloride, sodium and sulphate all exhibit high solubilities and will, therefore, exhibit a high potential for partitioning to surface water. Aluminum and chromium are considered to be virtually bound to the sediments under normal conditions (i.e. neutral pH), but their leachability from the sediment will increase with decreasing pH conditions. Appendix K presents a detailed discussion pertaining to fate and transport of the above compounds.

7.0 SUMMARY AND CONCLUSIONS

Based on the results of the CSA, the following summary and conclusions are made:

1) Historic underground utilities at the Facility are not considered to represent potential preferential routes of migration of contaminants.

2) The geologic units identified at the Site include in descending order of age:
   - glacial outwash;
   - glacial ice contact deposits;
   - glacial till; and
   - bedrock (fine grained sedimentary gneiss).

3) The glacial ice contact deposits ($k = 1 \times 10^{-2}$ cm/sec to 1×10^{-4} cm/sec) and outwash ($k = 1 \times 10^{-1}$ cm/sec to 1×10^{-3} cm/sec) function as the single, principal hydrostratigraphic unit in the area of the Site. The uppermost fractured portion of the bedrock surface beneath the Site is considered part of this flow system. Below the upper fractured bedrock, minor groundwater is transmitted along small fractures and joints.

4) The Site area encompasses portions of two hydrogeologic basins with the zone of regional groundwater divide separating these two basins located west and north of the Facility. East of the divide, the general groundwater flow direction is from northwest to southeast across the main part of the Facility. In the area of Plant B, groundwater flow is controlled by pumping an interceptor well system. Groundwater flow from the Facility discharges into the ditches bounding the Facility. West of the divide, the groundwater flow is directed to the west into the main portion of the regional aquifer.

5) Groundwater flow velocity on the Facility ranges between 100 feet to 325 feet per year. In the area west of the Facility but east of the divide,

groundwater flow velocity is approximately 10 feet/year. West of the zone of regional groundwater divide, groundwater flow velocity ranges between 10 feet to 425 feet per year.

6) The Site lies in both the headwaters of the Ipswich River and the Aberjona River watersheds. The surface water divide separating these two watersheds runs just west and north of the Facility, and closely parallels the groundwater divide.

7) There were three areas at the Facility which exhibited evidence of buried drum waste, miscellaneous waste and visibly contaminated soils. Materials within the test pits of the three areas were identified as Opex, Kempore, Phenolic resins, and Plant B material (diphenylamine). Organic compounds B2EHP, NNDPA and NNDNPA and inorganic compounds ammonia, calcium, chloride, chromium, iron, potassium, sodium and sulphate were the major parameters detected in the drums and/or soil samples.

8) The following compounds were detected in subsurface soils across the Facility:

VOCs: 244TM1P, 244TM2P, Toluene, 2-Butanone, 2-Hexanone and Acetone;

SVOCs: Bis(2-ethylhexyl)Phthalate (B2EHP), Butyl Benzylphthalate (BBZP), Di-n-Octylphthalate (DNBP) and N-Nitrosodiphenylamine (NNDPA); and

Inorganics: Ammonia, Calcium, Chromium (total), Potassium, Sodium and Sulphate

The highest concentrations of all the above compounds were detected in the central portion of the Facility in the area of former Lake Poly (SWMU No. 14).

9) The following compounds were detected in surface waters at the Facility:

VOCs: 244TM1P, 244TM2P, Toluene, 2-Hexanone and Acetone;

SVOCs: Bis(2-ethylhexyl)Phthalate (B2EHP), N-Nitrosodiphenylamine (NNDPA), and Phenol; and

Inorganics: Aluminum, Ammonia, Calcium, Chloride, Chromium (III and VI), Copper, Iron, Sodium, Sulphate and Zinc.

The highest concentrations of 244TM1P, 244TM2P, 2-Hexanone, Acetone, NNDPA, Phenol and all the inorganics except for iron, were detected in the West Ditch. The highest concentrations of B2EHP and iron were detected in the South Ditch.

10) The following major compounds were frequently detected in sediments at the Site:

VOCs: 244TM1P, 244TM2P, Toluene and Acetone;

SVOCs: Bis(2-ethylhexyl)Phthalate (B2EHP), Butyl Benzylphthalate (BBZP), Di-N-Octylphthalate (DNOP), Di-N-Butylphthalate (DNBP) and N-Nitrosodiphenylamine (NNDPA); and

Inorganics: Aluminum, Ammonia, Calcium, Chloride, Chromium (VI & total), Sodium and Sulphate.

The highest concentrations of all the above compounds were generally detected in the West Ditch and decreased across the Facility.

11) The presence of Toluene in surface water and TRCLE, 12DCE, CLC6H5, TCLEE and C2H3CL in surface sediments at location SW-23 in the East Ditch downstream of the Facility indicate an off-Site source.

12) A dense groundwater plume is seen emanating from the central portion of the Facility to just beyond Highway 38 (Main Street) to the west, edges just off the Facility boundary to the East Ditch and edges just off the southwest of the Facility in the vicinity of the Sulphate Landfill area. The plume is approximately 20 feet thick near wells GW-36 and GW-42D and thins to the west to approximately eight feet thick at GW-58D approximately 1,700 feet west of the Facility.

13) The following major Facility-related compounds were frequently detected in groundwater at the Site:

VOCs:	244TMIP, 244TM2P, Acetone, Toluene and Bromoform;
SVOCs:	Phthalate isomers, NNDPA, Phenolic Compounds; and
Inorganics:	Aluminum, Ammonia, Calcium, Chromium (VI and total), Chloride, Magnesium, Potassium, Sodium and Sulphate.

The VOCs and SVOCs are mainly limited to the Facility. The inorganic compounds ammonia, chloride, chromium and sulphate are the major Facility-related parameters associated with the off-Site dense plume.

14) Based on the knowledge of chemicals which were directed into the central portion of the property, this area is considered to be the primary source of the inorganic plume associated with the Facility.

15) Three factors are believed to have had the major influence over dense contaminant migration in the aquifer: the slope of the bedrock surface; the hydraulic forces generated from recharge of the wastewater into the

unlined pits and Lake Poly; and the dilution effects at the plume edge which control pH.

16) The organic contaminants found in the groundwater in the central portion of the Facility are most likely attributable to three sources: the discharge of yard and process spills and oily wastes to Lake Poly, the disposal of organic wastes to unlined pits, and the disposal of drums containing organic compounds beneath the ground surface.

17) In the area of monitoring well GW-49 east of the Facility, an off-Site source of organic contaminants is indicated, since no apparent correlation can be made between the Facility and the organic compounds detected in well GW-49.

8.0 RECOMMENDATIONS

Recommendations for future actions are not included as part of this CSA Phase II Field Investigations Report but will be provided as an Addendum to this report upon completion of the CSA Phase II Risk Assessment Report, currently being completed by ABB.

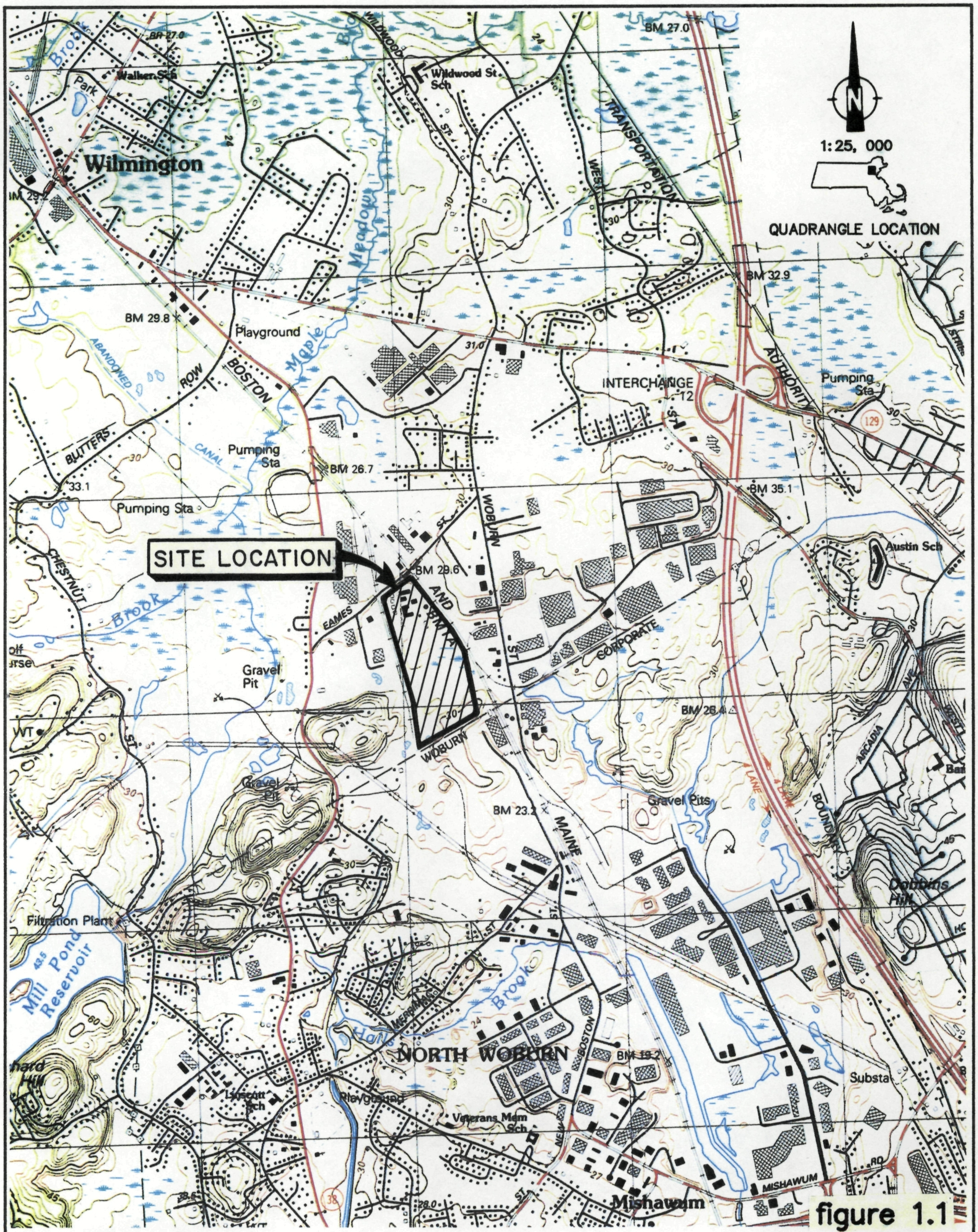
All of Which is Respectfully Submitted,

CONESTOGA-ROVERS & ASSOCIATES

Ed Roberts, P. Eng.

Jon Michels, B.A.

FIGURES



SOURCE : U.S. QUAD MAPS, 1987
42071-E1-TM-025

SITE LOCATION
WILMINGTON FACILITY
Olin Corporation

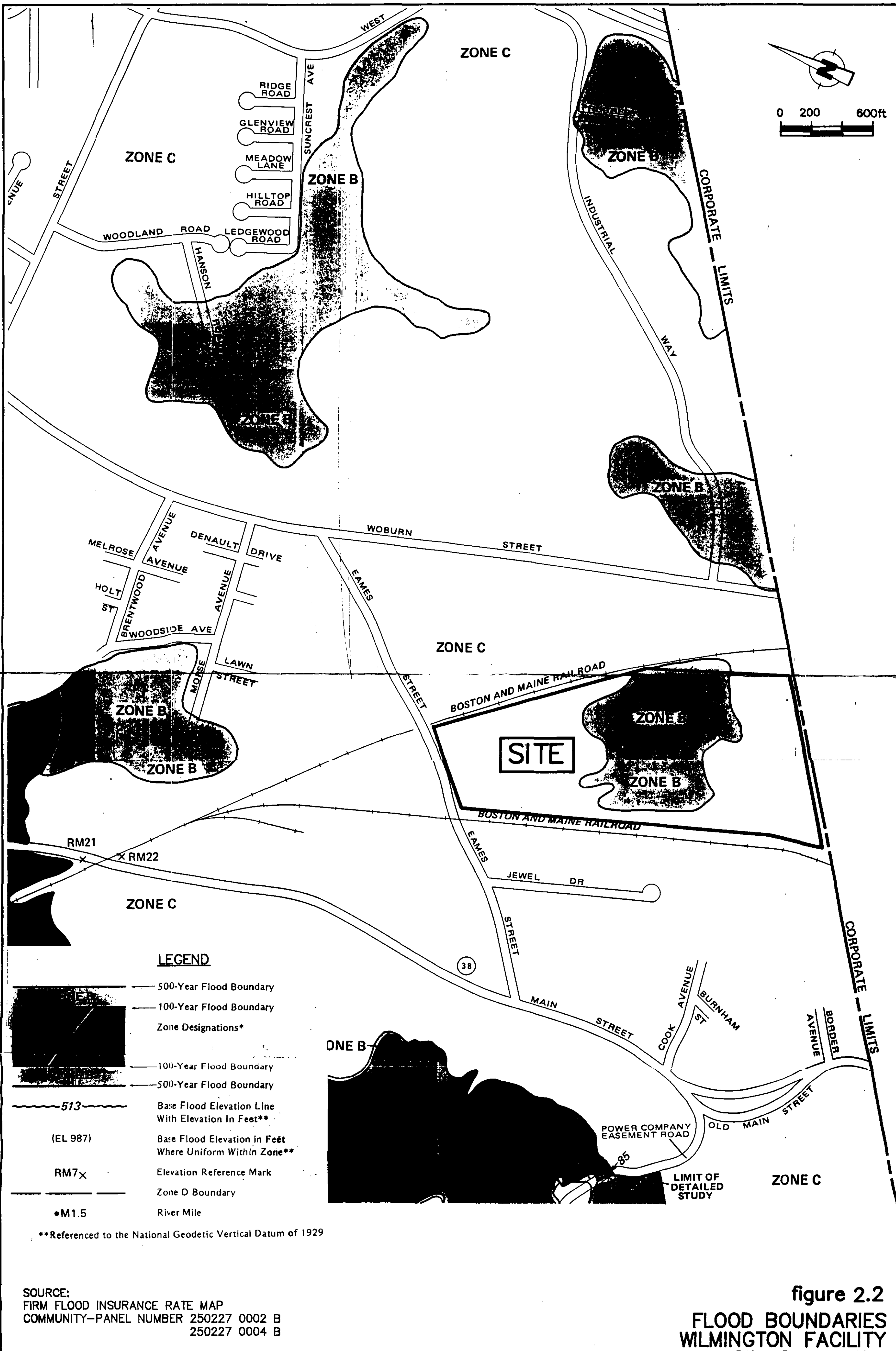
CRA

3683 (13) MARCH 05/93 REV.0 (W)

CRA

figure 2.1
1992 AERIAL PHOTOGRAPH
WILMINGTON FACILITY
Olin Corporation

3683 (13) MARCH 05/93 REV.0 (W)

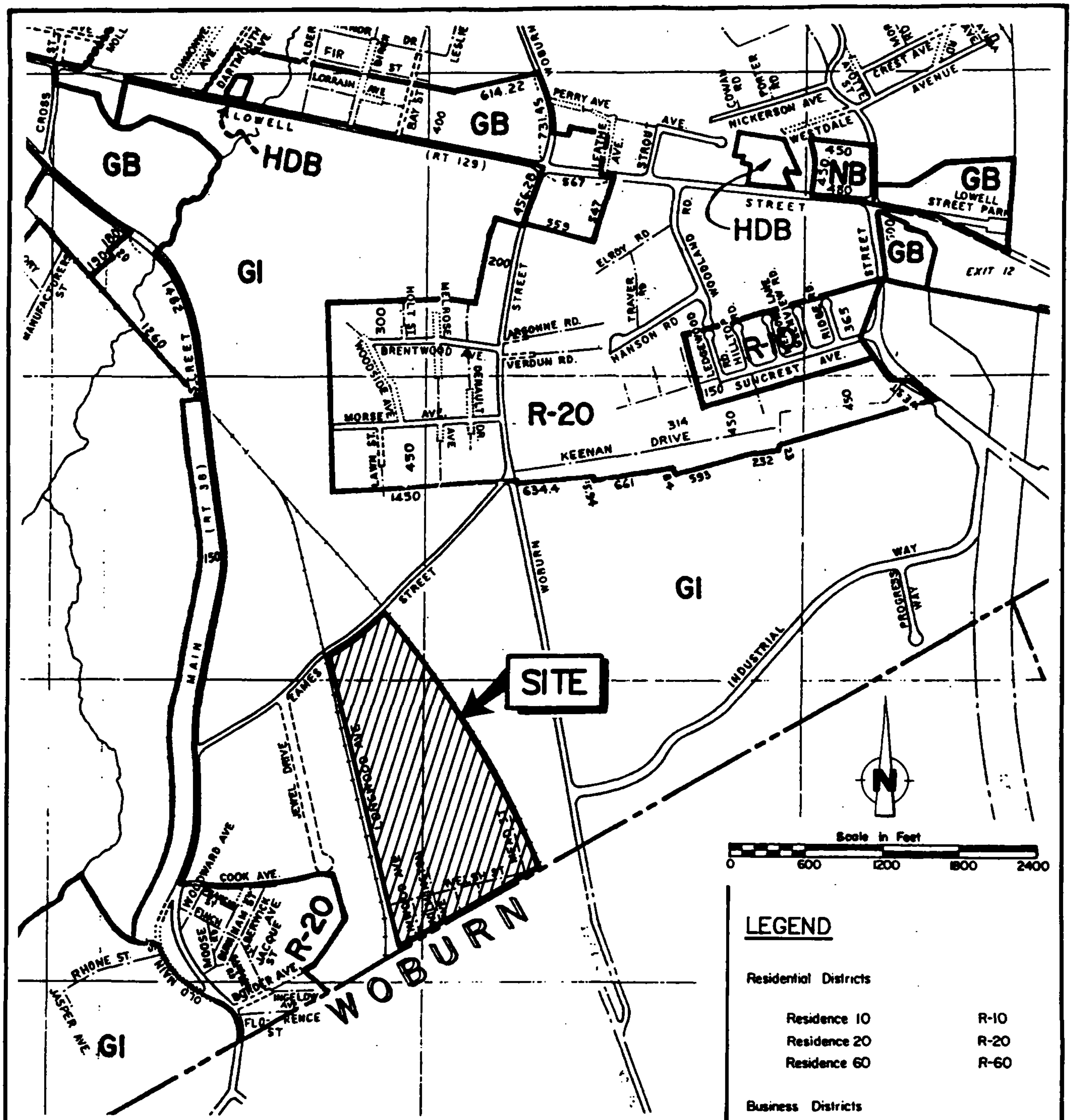


SOURCE:
FIRM FLOOD INSURANCE RATE MAP
COMMUNITY-PANEL NUMBER 250227 0002 B
250227 0004 B

CRA

figure 2.2
FLOOD BOUNDARIES
WILMINGTON FACILITY
Olin Corporation

3683 (13) MARCH 05/93 REV.0 (W)



SOURCE:

ZONING DISTRICT MAP
TOWN OF WILMINGTON
JANUARY 1983
CORRECTED TO
SEPTEMBER 28, 1987
MARCH 1, 1990
APRIL 27, 1991

LEGEND

Residential Districts

Residence 10	R-10
Residence 20	R-20
Residence 60	R-60

Business Districts

Neighborhood Business	NB
General Business	GB
High Density Business	HDB

Industrial Districts

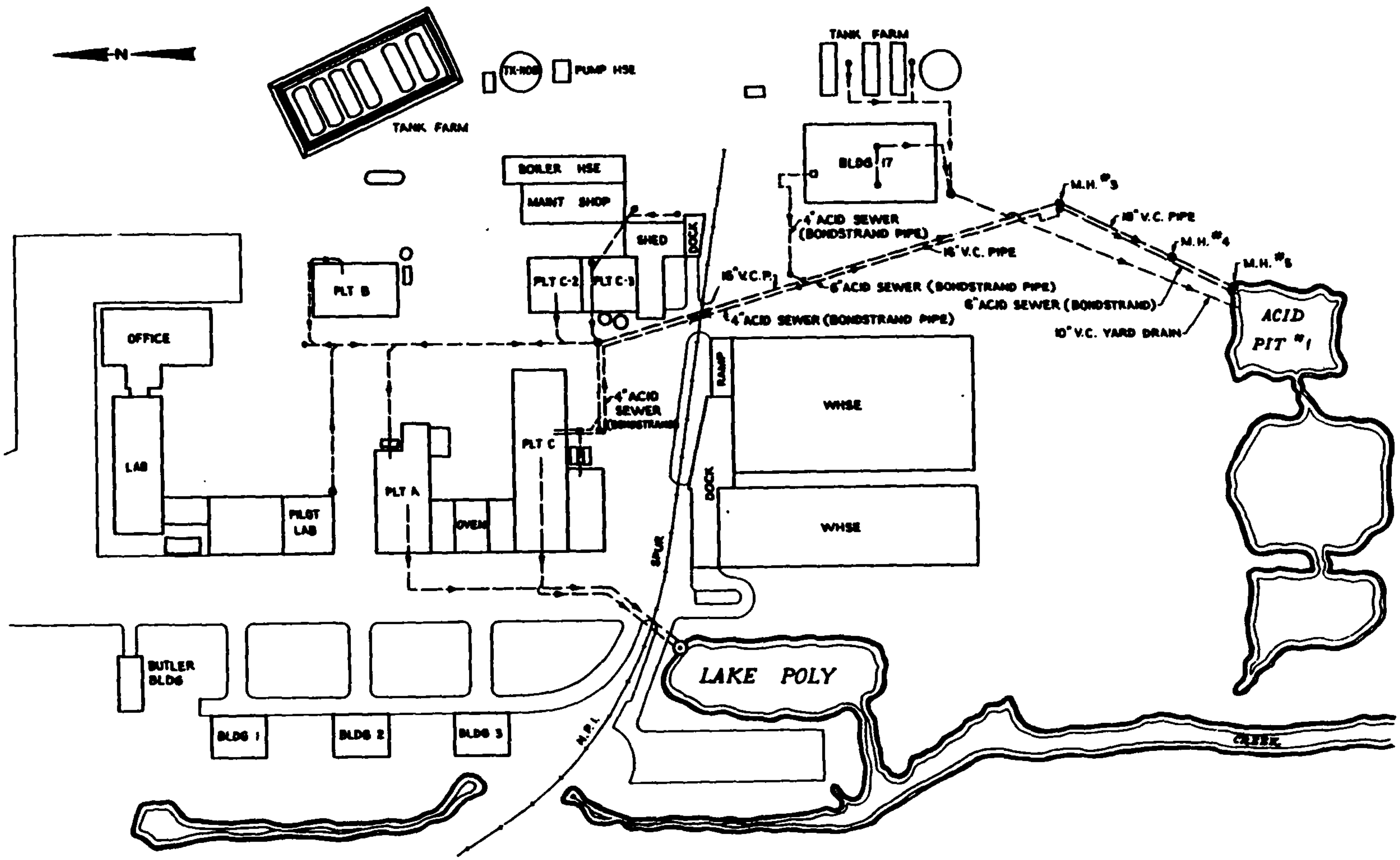
General Industrial	GI
Industrial Park	IP

figure 2.3

ZONING DISTRICT MAP
WILMINGTON FACILITY
Olin Corporation

CRA

3683(13) JUNE 15/93 (W) REV.0



SOURCE:

TECHNICAL REPORT
WASTEWATER CHARACTERIZATION STUDY
FOR
NATIONAL POLYCHEMICALS INC.
UNDER CONTRACT 43073
17 MARCH 1970

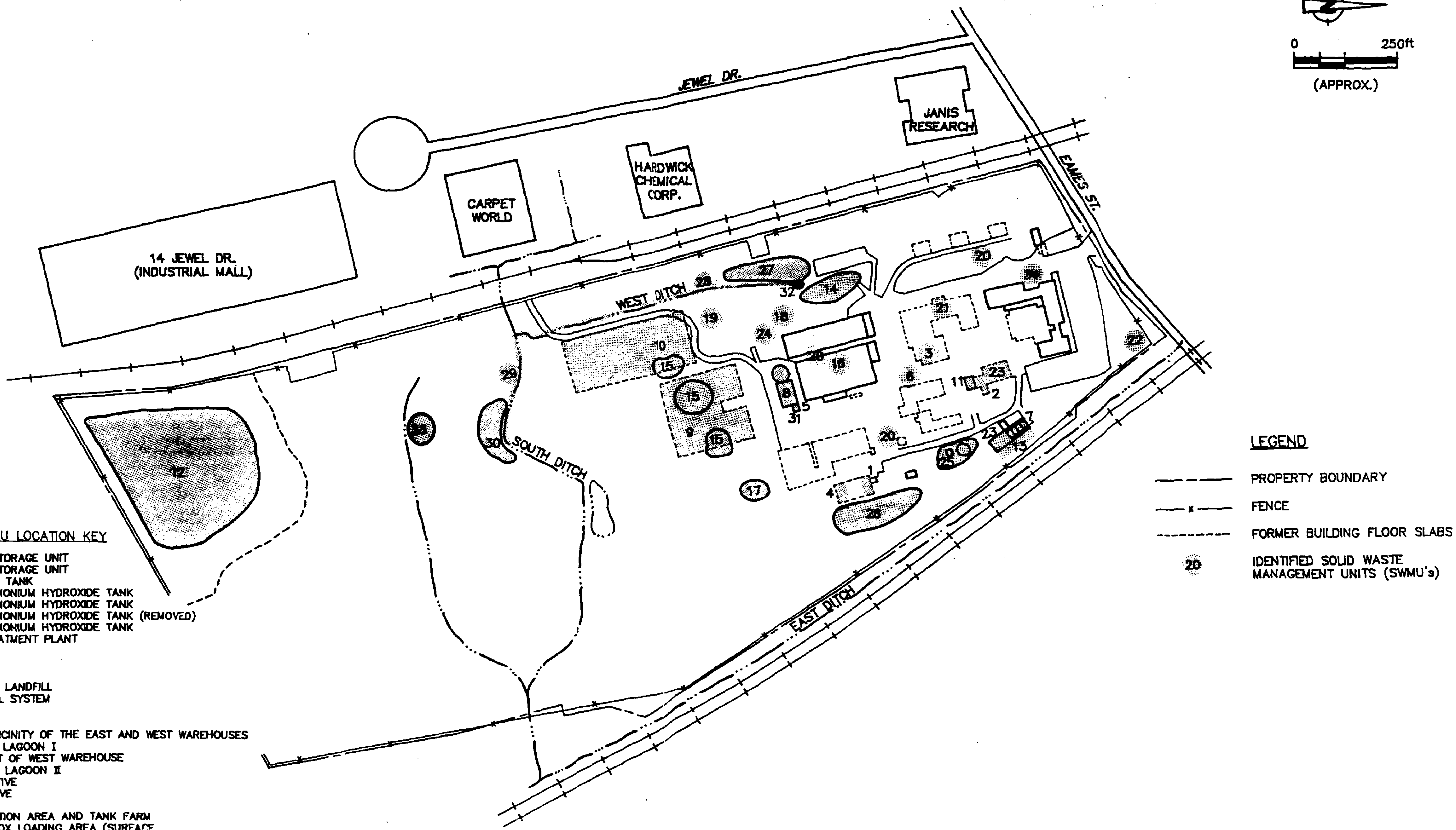
PREPARED BY
MARINE RESEARCH LABORATORY
NEW LONDON, CONN.
OF
RAYTHEON COMPANY
SUBMARINE SIGNAL DIVISION
PORTSMOUTH, RHODE ISLAND

CRA

figure 2.4

LOCATION OF ACID PITS AND LAKE POLY
WILMINGTON FACILITY
Olin Corporation

3683 (13) JUNE 11/93 REV.1 (W)



IDENTIFIED SWMU LOCATION KEY

1. PLANT D DRUM STORAGE UNIT
2. PLANT B DRUM STORAGE UNIT
3. BY-PRODUCT HCl TANK
4. BY-PRODUCT AMMONIUM HYDROXIDE TANK
5. BY-PRODUCT AMMONIUM HYDROXIDE TANK
6. BY-PRODUCT AMMONIUM HYDROXIDE TANK (REMOVED)
7. BY-PRODUCT AMMONIUM HYDROXIDE TANK
8. WASTEWATER TREATMENT PLANT
9. LAGOON I
10. LAGOON II
11. PLANT B PIT
12. CALCIUM SULFATE LANDFILL
13. INTERCEPTOR WELL SYSTEM
14. LAKE POLY
15. ACID PITS
16. TRENCH IN THE VICINITY OF THE EAST AND WEST WAREHOUSES
17. OPEX VICINITY OF LAGOON I
18. OPEX DRUMS WEST OF WEST WAREHOUSE
19. DRUMS NORTH OF LAGOON II
20. SEPTIC TANK, ACTIVE
21. TILE FIELD, INACTIVE
22. PCB CAPACITOR
23. PLANT B PRODUCTION AREA AND TANK FARM
24. SPILLS FROM WYTOX LOADING AREA (SURFACE SOIL REMOVED, MATERIAL IN WATER TABLE)
25. FUEL OIL SPILLS NEAR FIREWATER TANK
26. BLACK AREA EAST OF PLANT D (SURFACE SOIL REMOVED)
27. BLACK AREA NEAR WEST DITCH
28. WEST DITCH OILY MATERIAL UNDER SEDIMENT
29. SOUTH DITCH WHITE SEDIMENT AND OILY MATERIAL
30. BLACK OILY MATERIAL ON BANK OF SOUTH DITCH
31. WASTEWATER TREATMENT SUMP
32. OIL WATER SEPARATOR (NPDES DISCHARGE POINT)
33. AREA NEAR GW-55 WELL NEST
34. REMOVED FUEL TANK AREA

LEGEND

PROPERTY BOUNDARY

FENCE

FORMER BUILDING FLOOR SLABS

20 IDENTIFIED SOLID WASTE MANAGEMENT UNITS (SWMU's)

figure 2.5

IDENTIFIED SOLID WASTE MANAGEMENT UNITS (SWMU's)
WILMINGTON FACILITY
Olin Corporation

CRA
3683 (13) JUNE 11/93 REV.1 (W)

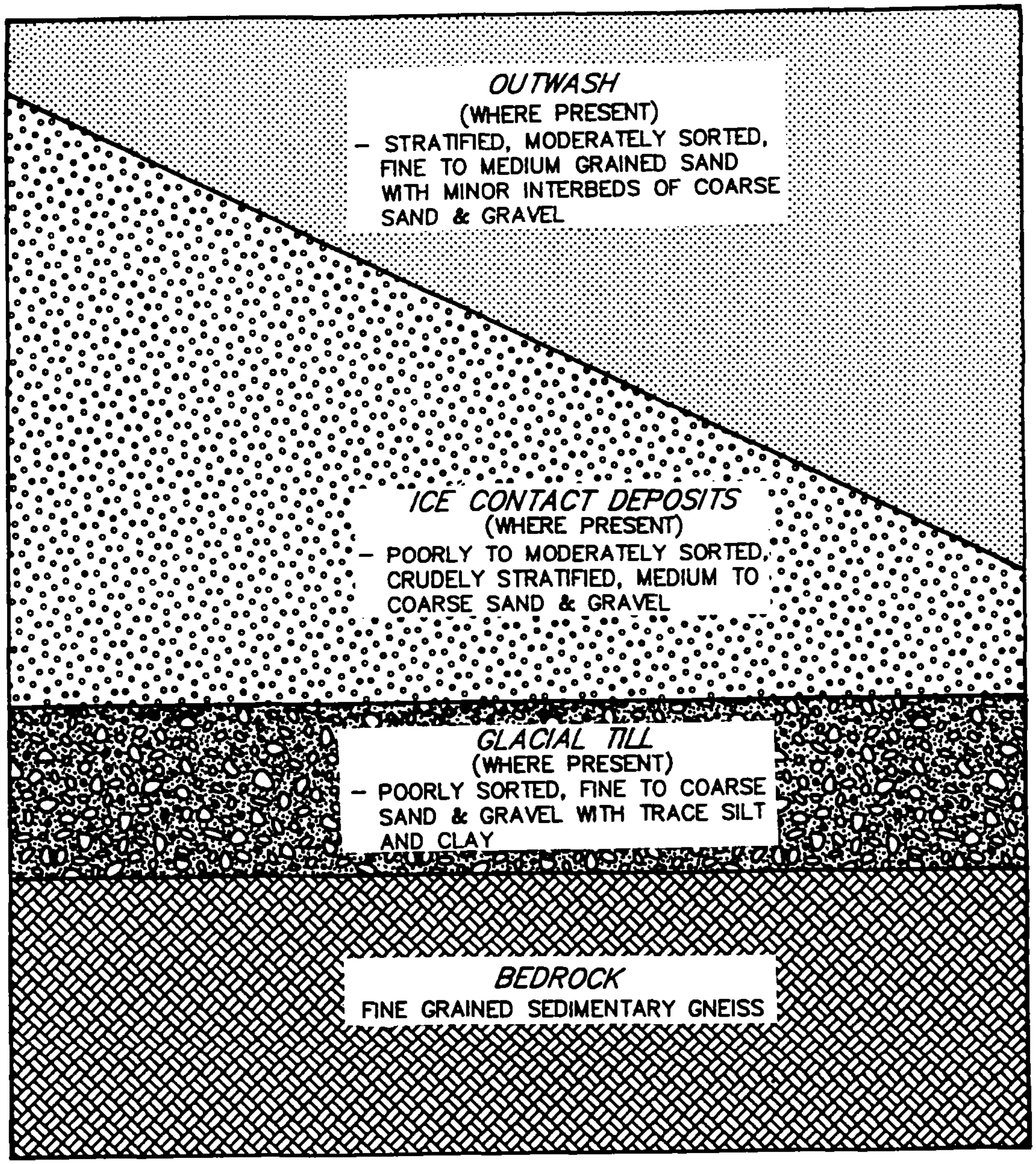
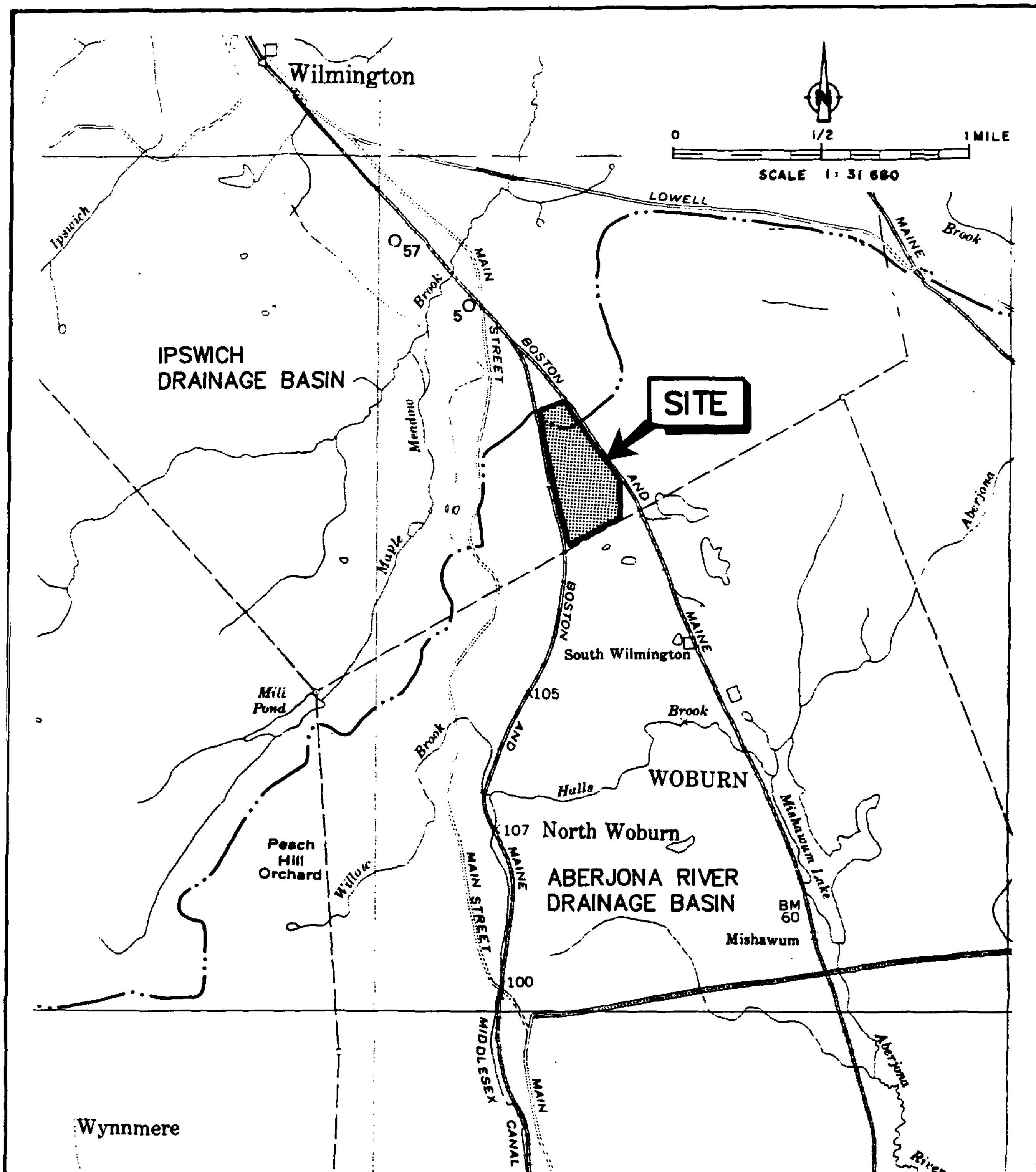


figure 3.1

GENERALIZED STRATIGRAPHIC SECTION
WILMINGTON FACILITY
Olin Corporation

CRA



LEGEND

—··— DIVIDE BETWEEN IPSWICH RIVER AND ABERJONA RIVER DRAINAGE BASINS

SOURCE: BASE FROM U.S. GEOLOGICAL SURVEY, SPECIAL MAPS BRANCH

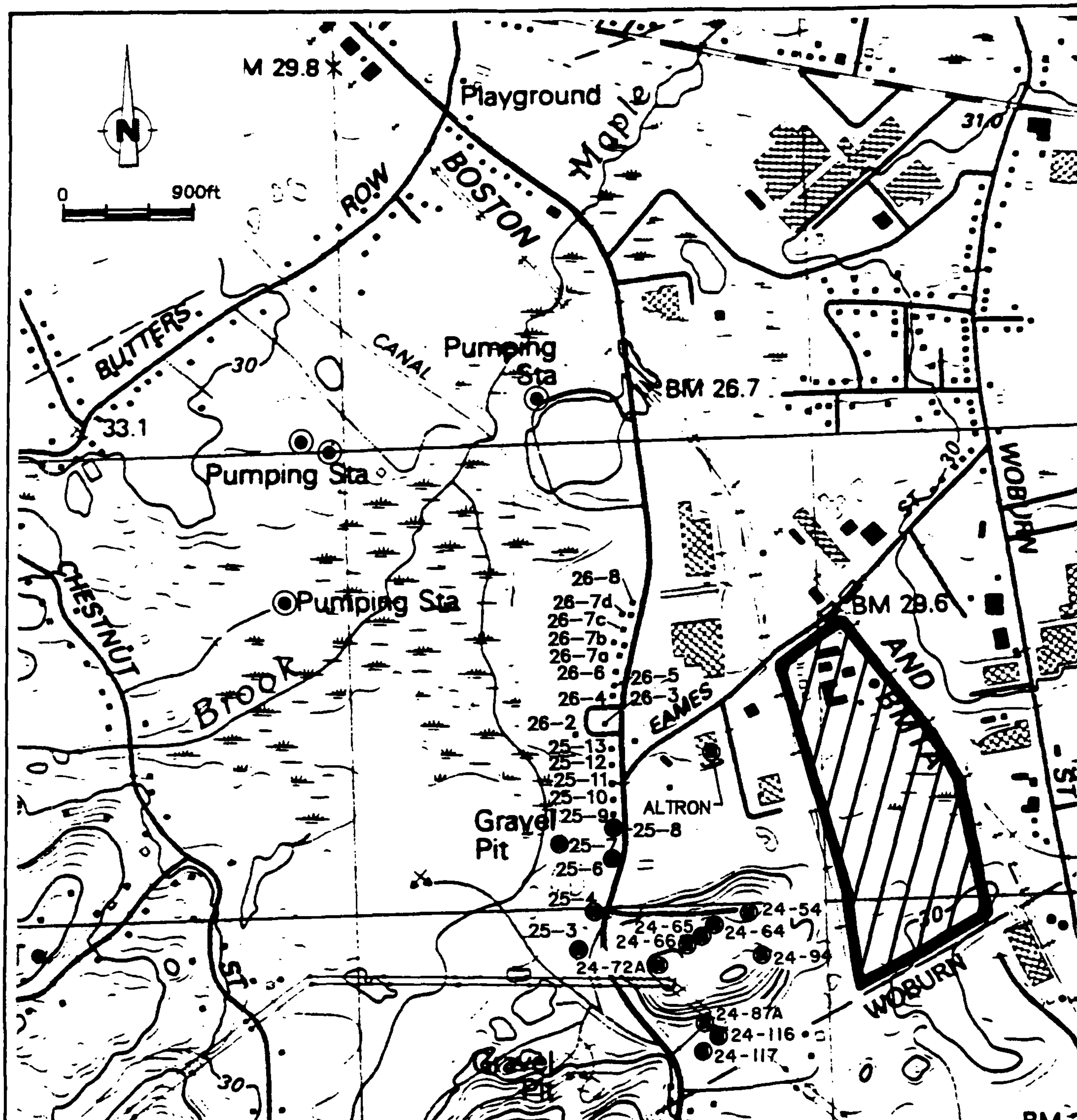
MAP OF WILMINGTON–READING AREA, MASSACHUSETTS, WATER-SUPPLY PAPER 1694 PLATE 1

figure 3.2

REGIONAL SURFACE DRAINAGE NETWORKS
WILMINGTON FACILITY
Olin Corporation

CRA

3683 (13) MARCH 08/93 REV.0 (W)



SOURCE: U.S. QUAD MAPS, 1987
42071-E1-TM-025

LEGEND

◎ WILMINGTON MUNICIPAL WATER SUPPLY WELL

26–3 ▪ PRIVATE RESIDENT LOCATIONS

● PRIVATE WELLS IDENTIFIED

figure 3.3

IDENTIFIED WELLS IN VICINITY OF FACILITY
WILMINGTON FACILITY
Olin Corporation

CRA

3683 (13) MARCH 05/93 REV.0 (W)

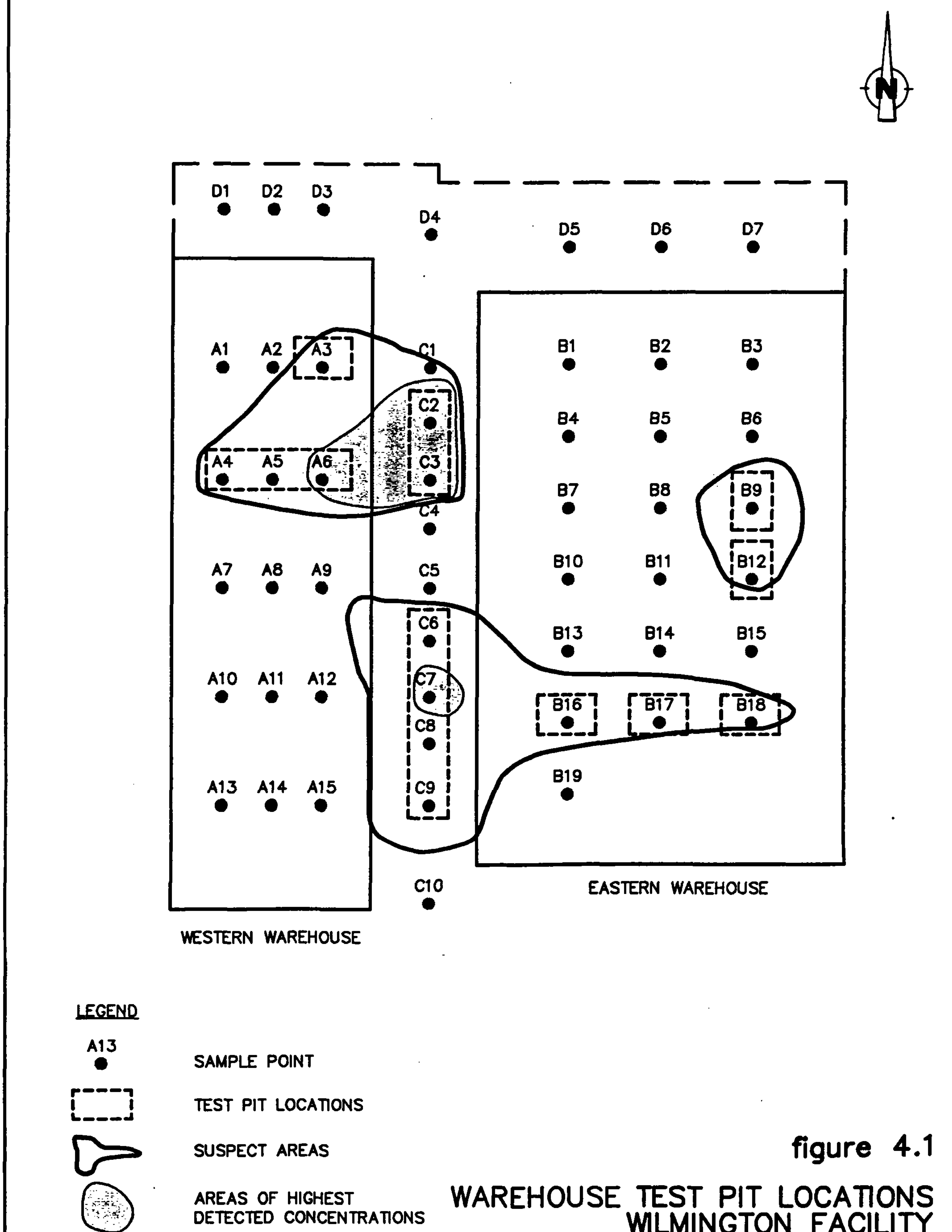


figure 4.1

WAREHOUSE TEST PIT LOCATIONS
WILMINGTON FACILITY
Olin Corporation

CRA

3683 (13) MARCH 05/93 REV.0 (W)

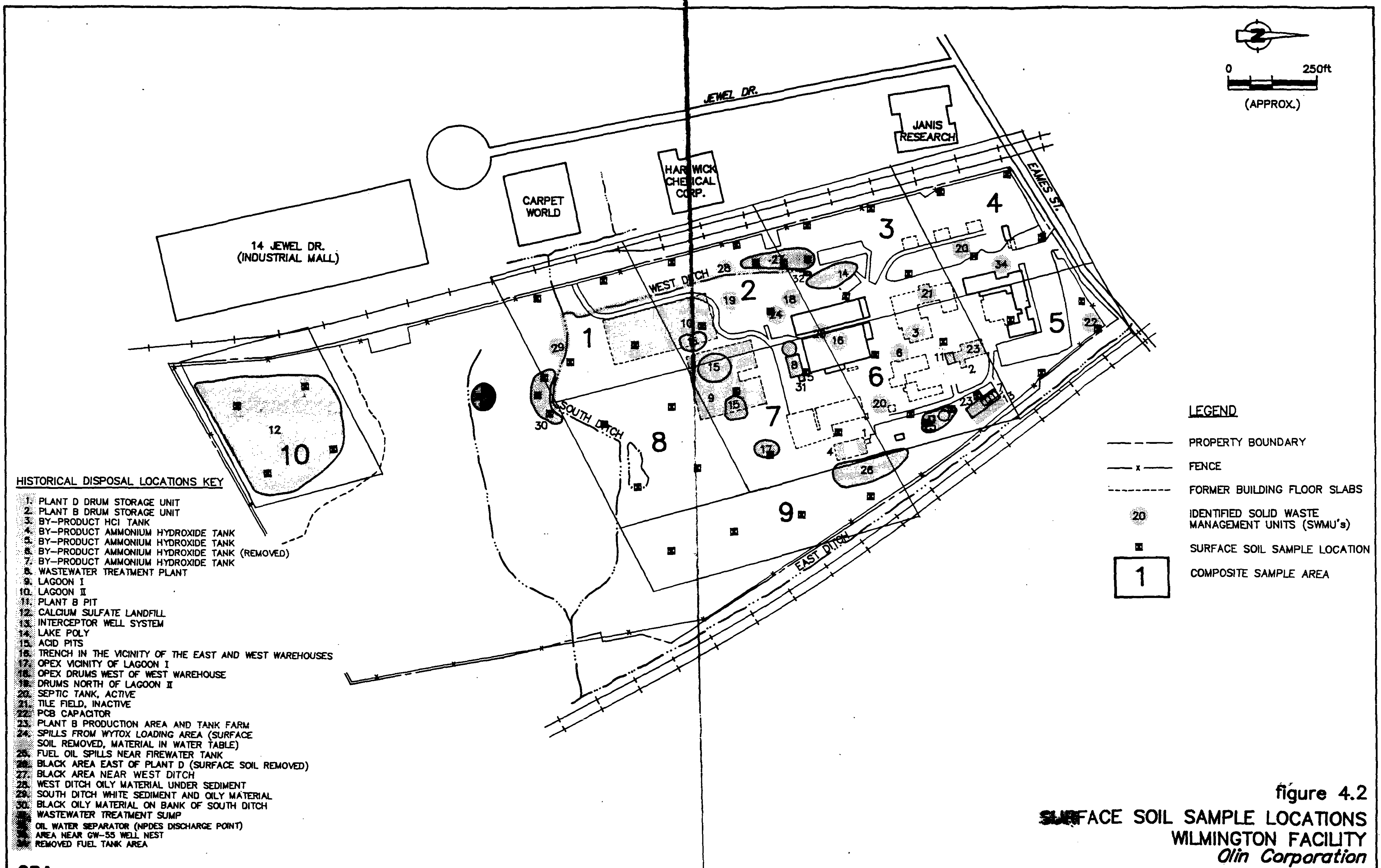


figure 4.2
SURFACE SOIL SAMPLE LOCATIONS
WILMINGTON FACILITY
Olin Corporation

CRA
3683 (13) JUNE 11/93 REV.1 (W)

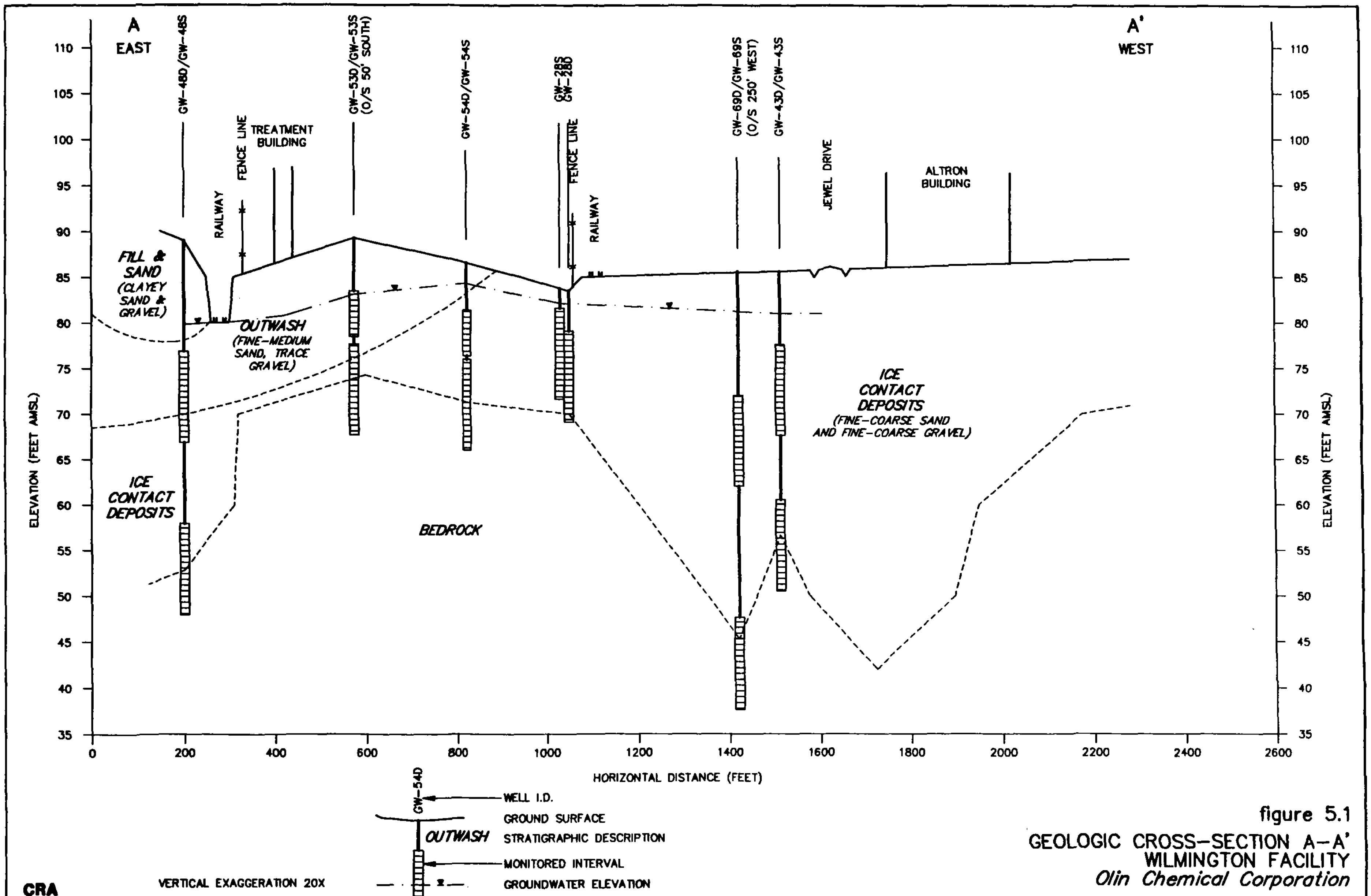


figure 5.1

GEOLOGIC CROSS-SECTION A-A'
WILMINGTON FACILITY
Olin Chemical Corporation

3683 (13) MAR 08/93 REV.0 (X-05)

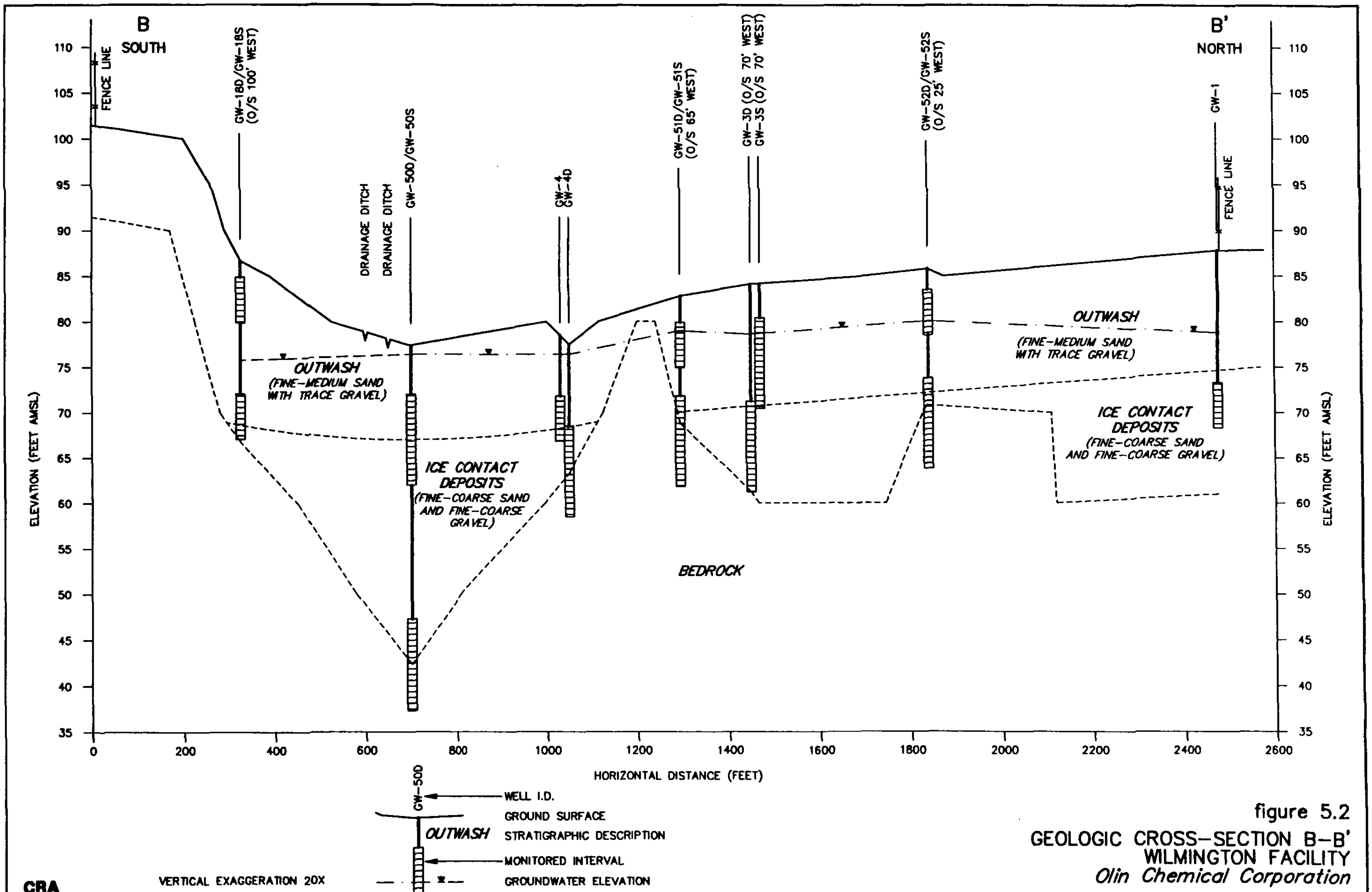


figure 5.2

GEOLOGIC CROSS-SECTION B-B'
WILMINGTON FACILITY
Olin Chemical Corporation

3683 (13) MAR 08/93 REV.0 (X-06)

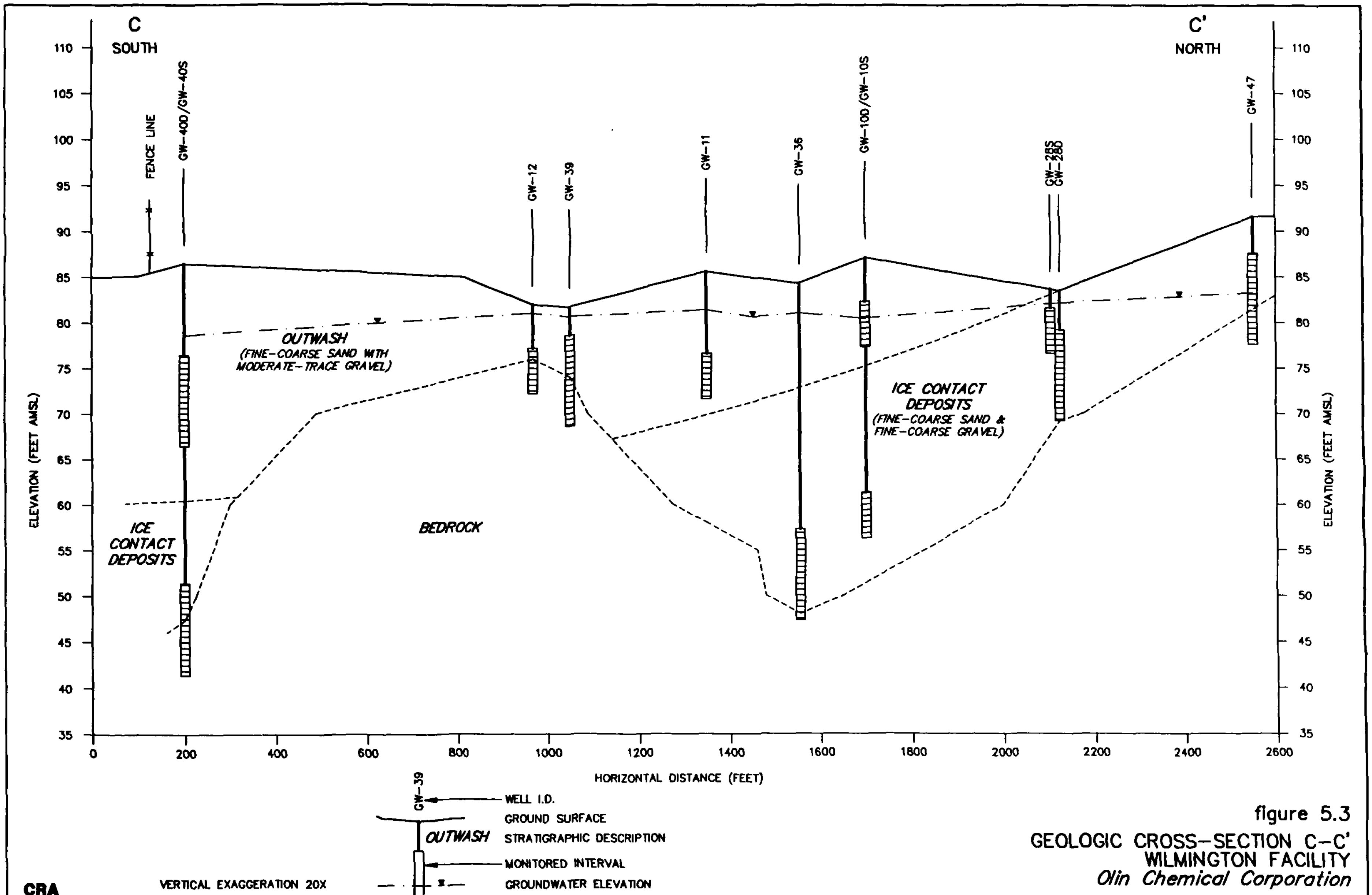


figure 5.3
GEOLOGIC CROSS-SECTION C-C'
WILMINGTON FACILITY
Olin Chemical Corporation

3683 (13) MAR 08/93 REV.0 (X-07)

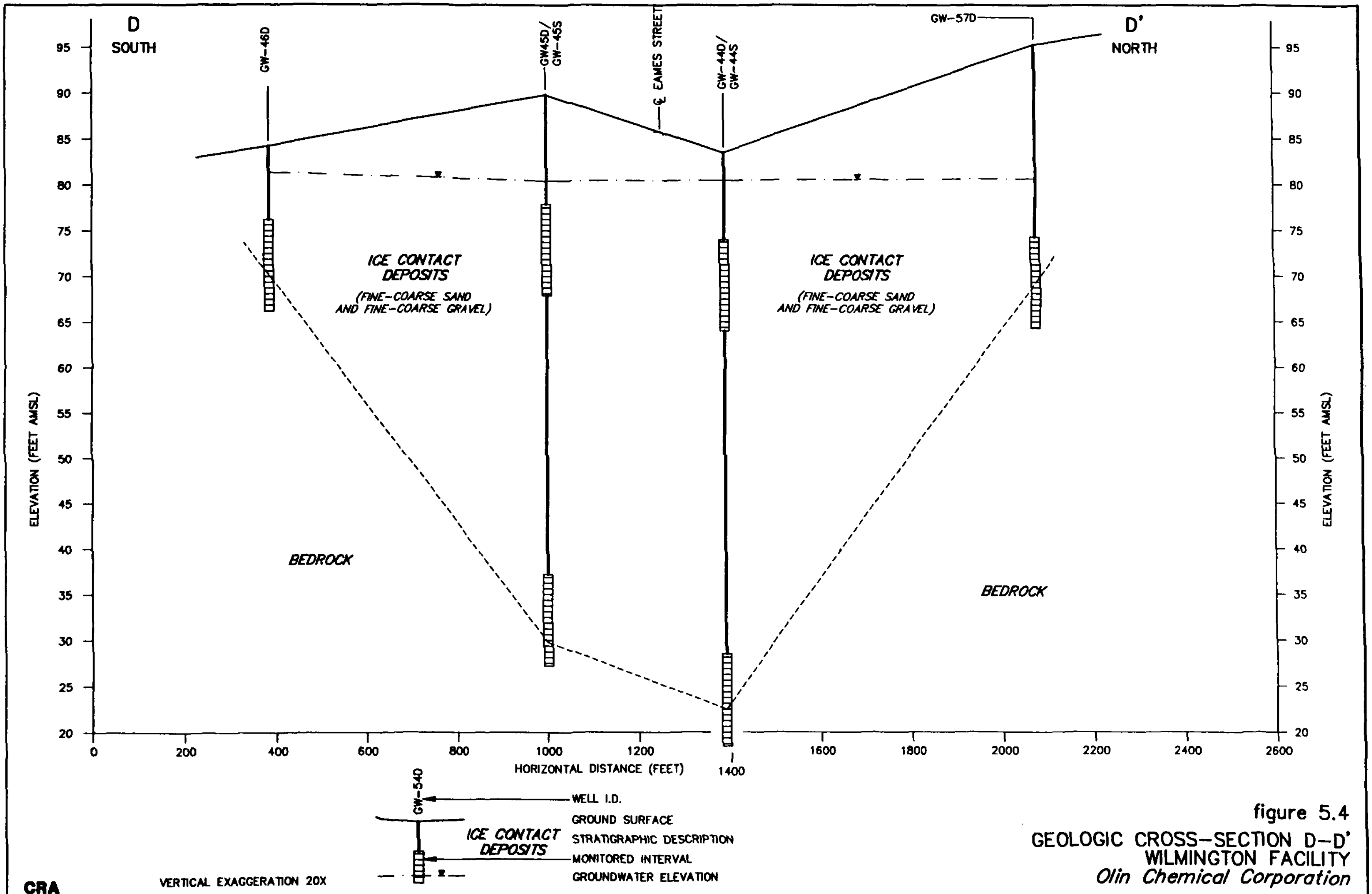


figure 5.4
GEOLOGIC CROSS-SECTION D-D'
WILMINGTON FACILITY
Olin Chemical Corporation

3683 (13) MAR 08/93 REV.0 (X-08)

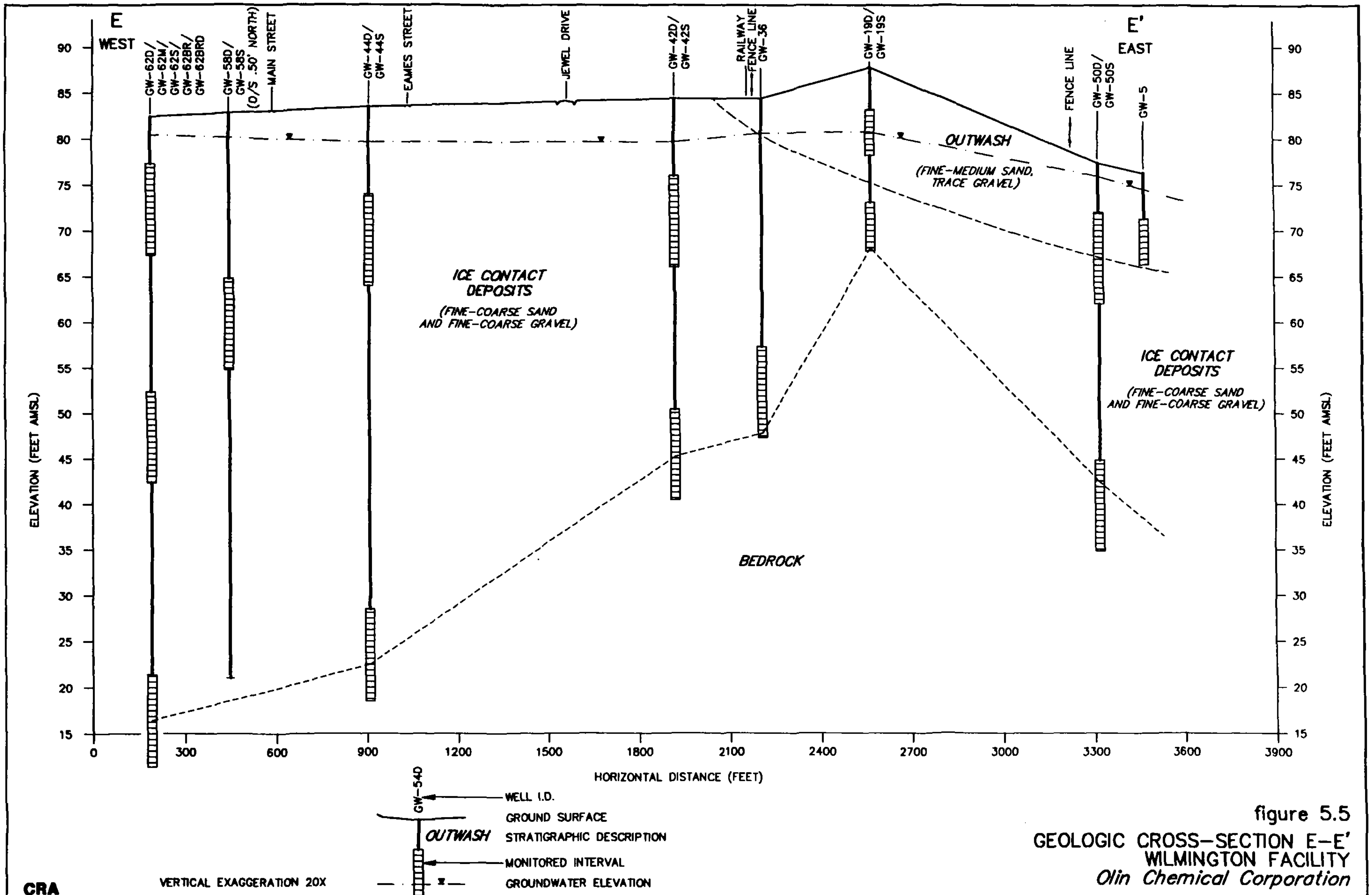


figure 5.5

GEOLOGIC CROSS-SECTION E-E'
WILMINGTON FACILITY
Olin Chemical Corporation

3683 (13) MAR 08/93 REV.0 (X-09)

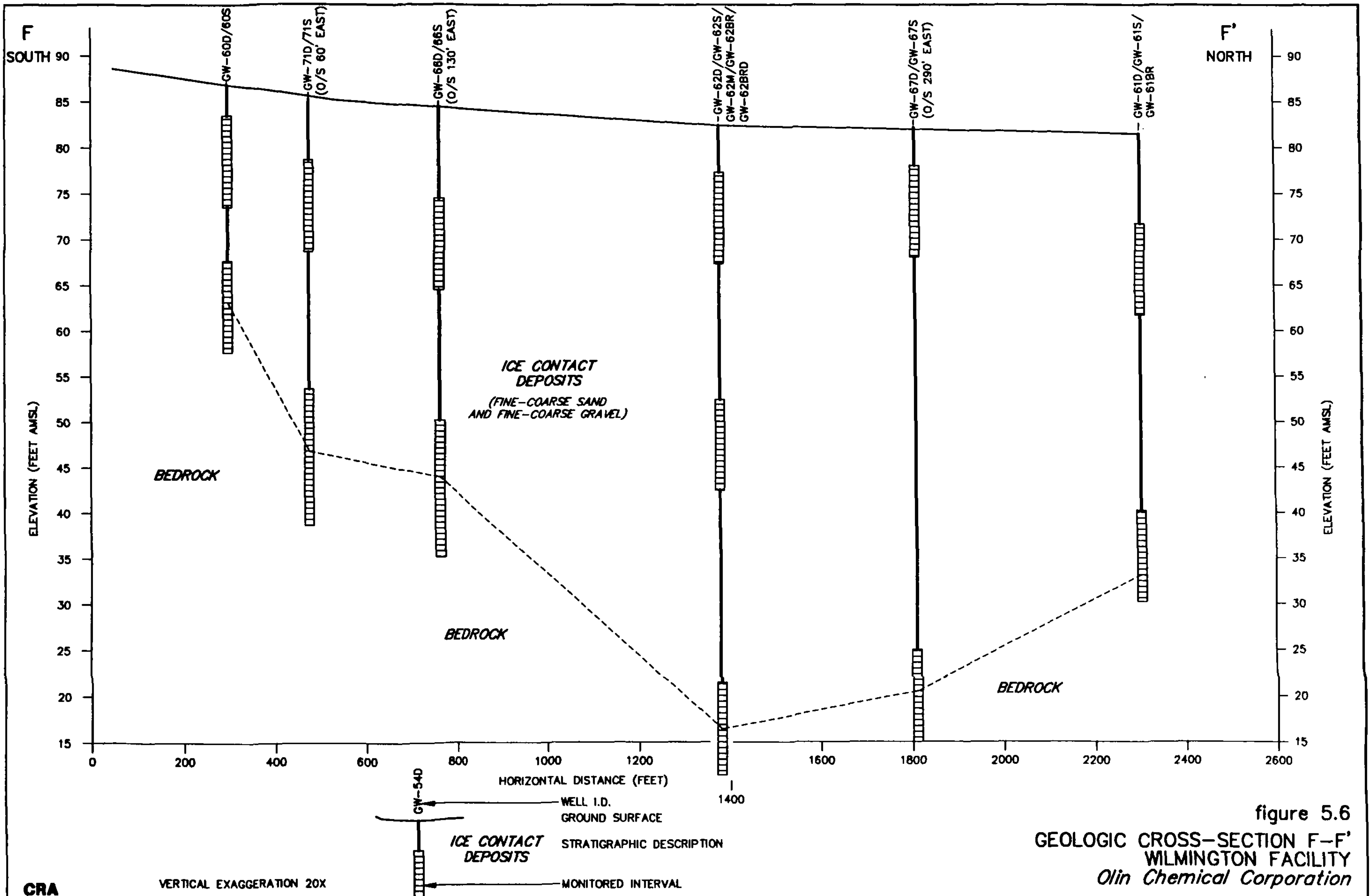


figure 5.6

GEOLOGIC CROSS-SECTION F-F'
WILMINGTON FACILITY
Olin Chemical Corporation

3683 (13) MAR 08/93 REV.0 (X-10)

TABLES

APPENDIX A

TOWN WELL/ALTON WELL
CONSTRUCTION DETAILS

TOWN WELL CONSTRUCTION DETAILS

TOWN OR CITY Wilming SITE DATE COMPLETED

LOCATION Rear of Bldg. near receiving dock

1 Log

B3 Well

DEPTH OF STRATUM	FORMATION FOUND EACH STRATUM	
-18'	Brown med. to coarse sand & gravel	free
18'-24'	Brown med. to coarse sand & gravel	free
-30'	Brown fine to med. sand	free
36'	Not refusal - high iron content - pulled back to 25' and set screen & developed	
	Note high Iron Content	

DIA. TEST WELL	2½"
STATIC WL FROM TOP PIPE	11'
STATIC WL FROM GROUND	11'
TOTAL DEPTH DRIVEN	36'
DEPTH DEVELOPED	25'
PIPE LEFT IN PLACE	18'
TYPE SCREEN	1 1/4" Gal. Johnson 60 slot
DEPTH SCREEN SET	20'-25'
DEVELOPED & RATED AT	75& G.P.M. 15" VAC.
WATER SAMPLE	
DATE COLLECTED	

REMARKS

Record of pumping test to determine specific yield

for 2nd mineral test

Pumped 75 g.p.m for 2 hr. from #2 observed ~~ft. in, drawdown in obs. ft. away at a depth of ft.~~

Pumped g.p.m for hr. from observed ft. in, drawdown in obs. ft. away at a depth of ft.

Specific yield of gallons per foot of drawdown

Well driven by [redacted]

SIGNED

IONPURE

WATER ANALYSIS LABORATORY
Ionpure Technologies Corporation
10 Technology Drive, Lowell, Massachusetts 01851
(800) 783-PURE (508) 934-9349

March 19, 1992

AGJC50883904 010430H

JOSEPH DATTILO
WT MANAGER
ALTRON, INC
1 JEWEL DRIVE
WILMINGTON MA 01887

CUSTOMER NAME:	JOSEPH DATTILO
CUSTOMER COMPANY:	ALTRON, INC
CUSTOMER CITY/STATE:	WILMINGTON MA
SAMPLING DATE:	10-MAR-92
SAMPLE DESCRIPTION:	B1 WELL
WATER SAMPLE SOURCE:	RAW PRIVATE WELL WATER
BILLING INFORMATION:	PURCHASE ORDER NUMBER 229307-62
IONPURE ID NUMBER:	920532

TEST: RO/CDI TROUBLESHOOTING ANALYSIS (TEST 354 00)

CATIONS			ANIONS		
	PPM IONS	PPM CaCO3		PPM IONS	PPM CaCO3
Ca	19.07	47.67	OH	0.00	0.00
Mg	4.11	16.93	CO3	0.00	0.00
Na	75.70	165.03	HCO3	29.27	24.00
K	2.55	3.26	SO4	188.20	195.73
Fe	0.011	0.03	Cl	116.40	164.12
Cu	0.01	0.02	NO3	13.20	10.69
Ba	0.05	0.04	F	0.00	0.00
Mn	0.950	1.73			
Sr	0.14	0.16			
Al	0.036	0.200			
TOTAL		235.07	TOTAL		394.54

SiO2 (PPM SiO2) 10.39 SiO2 (PPM AS CaCO3) 8.63

TOTAL HARDNESS PPM AS CaCO3 64.61

TOTAL ALKALINITY PPM AS CaCO3 24.00

CARBON DIOXIDE PPM AS CaCO3 45.28

pH (UNITS) 6.1

ADDITIONAL SAMPLE INFORMATION:

CHROMIUM = < 0.010 PPM
AMMONIA = 53.7 PPM

NOTE1: THE ABOVE RESULTS ARE REPRESENTATIVE OF THE WATER SAMPLE ON THE DAY THE TESTS WERE PERFORMED.

THANK YOU FOR CHOOSING IONPURE TECHNOLOGIES CORPORATION,

Steven F. Boyer

STEVEN F. BOYER

MANAGER, WATER ANALYSIS LABORATORY

CERTIFIED LABORATORY MA070
THE COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENVIRONMENTAL PROTECTION

IONPURE

WATER ANALYSIS LABORATORY
Ionpure Technologies Corporation
10 Technology Drive, Lowell, Massachusetts 01851
(800) 783-PURE (508) 934-9349

March 19, 1992

MGJC50884140 01043CH

JOSEPH DATTILO
WT MANAGER
ALTRON, INC
1 JEWEL DRIVE
WILMINGTON MA 01887

CUSTOMER NAME:	JOSEPH DATTILO
CUSTOMER COMPANY:	ALTRON, INC
CUSTOMER CITY/STATE:	WILMINGTON MA
SAMPLING DATE:	10-MAR-92
SAMPLE DESCRIPTION:	B1 CITY
WATER SAMPLE SOURCE:	RAW MUNICIPAL WELL WATER
BILLING INFORMATION:	PURCHASE ORDER NUMBER 229307-62
IONPURE ID NUMBER:	920530

TEST: RO/CDI TROUBLESHOOTING ANALYSIS (TEST 354 00)

	CATIONS			ANIONS	
	PPM IONS	PPM CaCO3		PPM IONS	PPM CaCO3
Ca	32.10	80.25	OH	0.00	0.00
Mg	4.14	17.06	CO3	0.00	0.00
Na	31.85	69.43	HCO3	39.02	32.00
K	2.90	3.71	SO4	61.50	63.96
Fe	0.008	0.02	Cl	52.80	74.45
Cu	0.04	0.06	NO3	2.90	2.35
Ba	0.02	0.01	F	0.00	0.00
Mn	0.014	0.03			
Sr	0.10	0.11			
Al	0.028	0.156			
TOTAL		170.84	TOTAL		172.76

SiO2 (PPM SiO2) 10.27 SiO2 (PPM AS CaCO3)	8.52
TOTAL HARDNESS PPM AS CaCO3	97.31
TOTAL ALKALINITY PPM AS CaCO3	32.00
CARBON DIOXIDE PPM AS CaCO3	2.24
pH (UNITS)	7.5

ADDITIONAL SAMPLE INFORMATION:

CHROMIUM = < 0.010 PPM
AMMONIA = 0.21 PPM

NOTE1: THE ABOVE RESULTS ARE REPRESENTATIVE OF THE WATER SAMPLE ON THE DAY THE TESTS WERE PERFORMED.

THANK YOU FOR CHOOSING IONPURE TECHNOLOGIES CORPORATION,

Steven F. Boyer

STEVEN F. BOYER

MANAGER, WATER ANALYSIS LABORATORY

CERTIFIED LABORATORY MA070
THE COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENVIRONMENTAL PROTECTION

IONPURE

WATER ANALYSIS LABORATORY
Ionpure Technologies Corporation
10 Technology Drive, Lowell, Massachusetts 01851
(800) 783-PURE (508) 934-9349

March 19, 1992

NGJC50663889 010430H

JOSEPH DATTILO
WT MANAGER
ALTRON, INC
1 JEWEL DRIVE
WILMINGTON MA 01887

CUSTOMER NAME:	JOSEPH DATTILO		
CUSTOMER COMPANY:	ALTRON, INC		
CUSTOMER CITY/STATE:	WILMINGTON	MA	
SAMPLING DATE:	10-MAR-92		
SAMPLE DESCRIPTION:	B3 WELL		
WATER SAMPLE SOURCE:	RAW PRIVATE WELL WATER		
BILLING INFORMATION:	PURCHASE ORDER NUMBER		229307-62
IONPURE ID NUMBER:	920531		

TEST: RO/CDI TROUBLESHOOTING ANALYSIS (TEST 354 00)

CATIONS			ANIONS		
	PPM IONS	PPM CaCO3		PPM IONS	PPM CaCO3
Ca	20.10	50.25	OH	0.00	0.00
Mg	4.18	17.22	CO3	0.00	0.00
Na	85.40	186.17	HCO3	19.51	16.00
K	4.44	5.68	SO4	85.10	88.50
Fe	0.027	0.07	Cl	126.40	178.22
Cu	0.07	0.11	NO3	5.80	4.70
Ba	0.04	0.03	F	0.00	0.00
Mn	3.640	6.62			
Sr	0.15	0.17			
Al	0.038	0.211			
TOTAL		266.55	TOTAL		287.43

SiO2 (PPM SiO2)	9.79	SiO2 (PPM AS CaCO3)	8.12
TOTAL HARDNESS PPM AS CaCO3			67.47
TOTAL ALKALINITY PPM AS CaCO3			16.00
CARBON DIOXIDE PPM AS CaCO3			61.12
pH (UNITS)			5.8

ADDITIONAL SAMPLE INFORMATION:

CHROMIUM = < 0.010 PPM
AMMONIA = 9.6 PPM

NOTE1: THE ABOVE RESULTS ARE REPRESENTATIVE OF THE WATER SAMPLE ON THE DAY THE TESTS WERE PERFORMED.

THANK YOU FOR CHOOSING IONPURE TECHNOLOGIES CORPORATION,

Steven F. Boyer

STEVEN F. BOYER

MANAGER, WATER ANALYSIS LABORATORY

CERTIFIED LABORATORY MA070
THE COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENVIRONMENTAL PROTECTION

IONPURE

WATER ANALYSIS LABORATORY
Ionpure Technologies Corporation
10 Technology Drive, Lowell, Massachusetts 01851
(800) 783-PURE (508) 934-9349

March 19, 1992

IGJC50884556 010430H

JOSEPH DATTILO
WT MANAGER
ALTRON, INC
1 JEWEL DRIVE
WILMINGTON MA 01887

CUSTOMER NAME:	JOSEPH DATTILO
CUSTOMER COMPANY:	ALTRON, INC
CUSTOMER CITY/STATE:	WILMINGTON MA
SAMPLING DATE:	10-MAR-92
SAMPLE DESCRIPTION:	B3 CITY
WATER SAMPLE SOURCE:	RAW MUNICIPAL WELL WATER
BILLING INFORMATION:	PURCHASE ORDER NUMBER 229307-62
IONPURE ID NUMBER:	920529

TEST: RO/CDI TROUBLESHOOTING ANALYSIS (TEST 354 00)

CATIONS			ANIONS		
	PPM IONS	PPM CaCO3		PPM IONS	PPM CaCO3
Ca	32.30	80.75	OH	0.00	0.00
Mg	4.28	17.63	CO3	0.00	0.00
Na	34.58	75.38	HCO3	39.02	32.00
K	2.75	3.52	SO4	60.70	63.13
Fe	0.043	0.12	Cl	55.90	78.82
Cu	0.03	0.05	NO3	2.90	2.35
Ba	0.01	0.01	F	0.00	0.00
Mn	0.013	0.02			
Sr	0.10	0.11			
Al	0.030	0.167			
TOTAL		177.77	TOTAL		176.30

SiO2 (PPM SiO2) 9.53 SiO2 (PPM AS CaCO3) 7.91

TOTAL HARDNESS PPM AS CaCO3 98.38

TOTAL ALKALINITY PPM AS CaCO3 32.00

CARBON DIOXIDE PPM AS CaCO3 2.24

pH (UNITS) 7.5

ADDITIONAL SAMPLE INFORMATION:

CHROMIUM = < 0.010 PPM
AMMONIA = 0.34 PPM

NOTE1: THE ABOVE RESULTS ARE REPRESENTATIVE OF THE WATER SAMPLE ON THE DAY THE TESTS WERE PERFORMED.

THANK YOU FOR CHOOSING IONPURE TECHNOLOGIES CORPORATION,

Steven F. Boyer

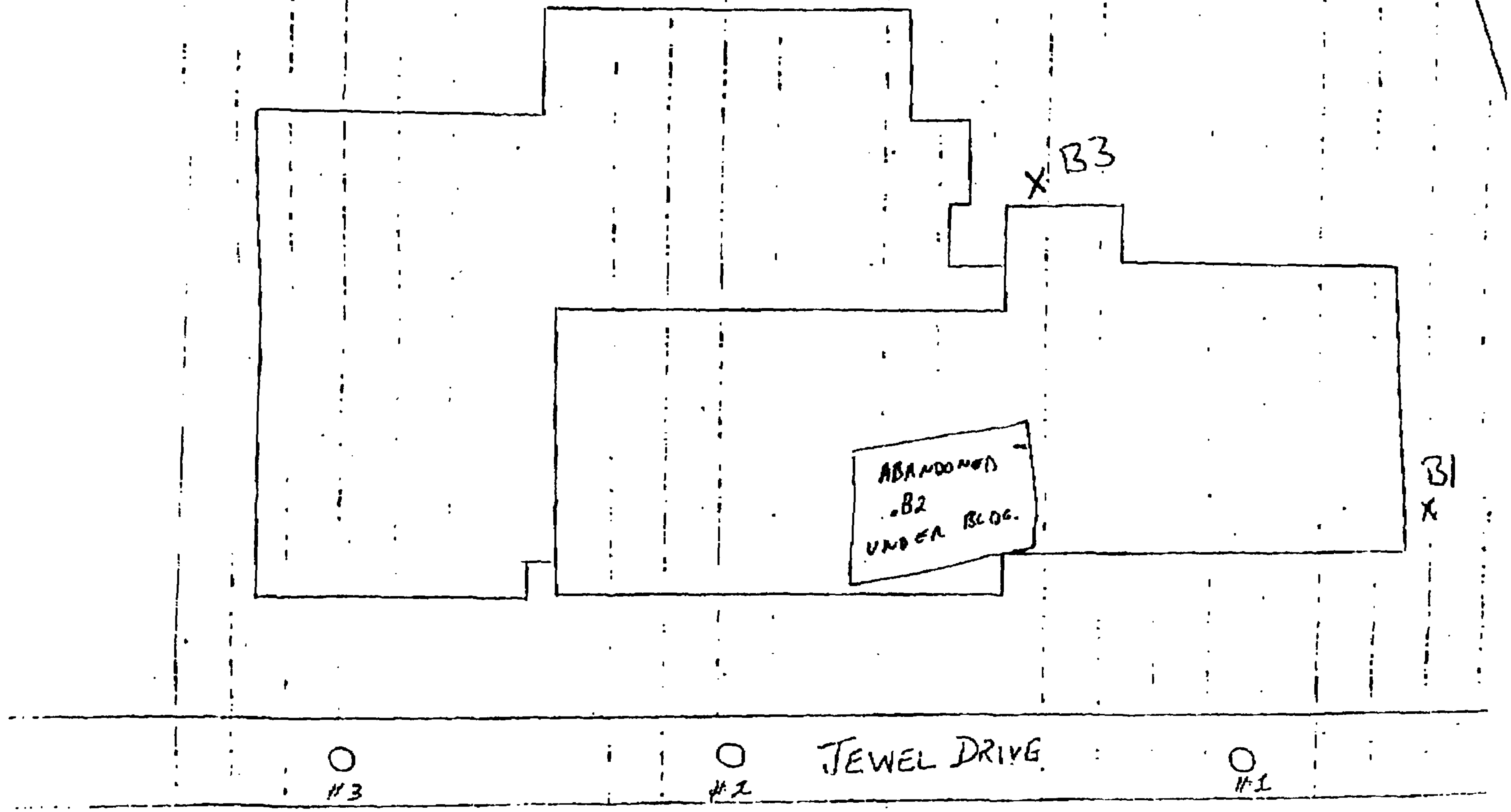
STEVEN F. BOYER

MANAGER, WATER ANALYSIS LABORATORY

CERTIFIED LABORATORY MA070
THE COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENVIRONMENTAL PROTECTION

B1 & BW wells
Depth 28' ± 2'
Flow App 50,000 gPD each
"PROCESS WATER" ONLY

ALTRON INC.
SITE PLAN



TOWN OR CITY Wilmingt __SITE____________DATF 'O

LOCATION Right front corner of building looking from

Test hole Log

B1 Well

DEPTH OF STRATUM	FORMATION FOUND EACH STRATUM	
0'-8'	medium to coarse sand & gravel with	DIA. TEST WE
	large boulders	STATIC WL FF
8'-54'	brown medium to coarse sand	STATIC WL FR
54'-67'	gray medium to coarse sand	TOTAL DEPTH
67'	REFUSAL	DEPTH DEVEL
		PIPE LEFT IN
		TYPE SCREEN
		DEPTH SCREE
		DEVELOPED &
	Pumped 40 gpm at 66' with green water	30 G.P.
	and high iron	WATER SAMPL
	Pulled back to 57' with high iron	DATE COLLEC
	Pulled back to 30' and developed	RI

Record of pumping test to determine specific yield

Pumped____g.p.m for__hr. from_______observed___ft.__in, drawdown in obs.___ft. away at a de

Pumped____g.p.m for__hr. from_______observed___ft.__in, drawdown in obs.___ft. away at a de

Specific yield of_____gallons per foot of drawdown

Well driven by L. N. Osborne

SIGNED______________

ALTON WELL LOGS/
AVAILABLE DATA

rcent of Water Pumped**	81%	80.2%	87.54%	95.19%	76.60%	83%

Residential use includes small commercial users, that is, all water passing through 5/8" meters.

**The difference between the water pumped and the water metered, 173,134,148 gallons in 1989, represents water used for flushing of water mains, flushing and filling new water mains, for fires, street sweeping and other hydrant uses, testing new water treatment plant before acceptance by department and water lost due to in breaks.

WATER DISTRIBUTION SYSTEM

e following new mains were constructed during 1989:

Street	Amount	Size	Hydrants
Olmstead Avenue	375'	6"	1
Marrietta Avenue	750'	8"	2
Pearl Court	225'	6"	0
Crystal Road	950'	8"	3
Whitefield Elms	1650'	12"	5
Andover Street	475'	12"	1
Dunmore Road	300'	6"	1
Waltham Street	370'	6"	1
Upton Court	240'	12"	0
Hall Street	123'	8"	1
Dewey Avenue	200'	6"	0
Naples Road	300'	6"	1
Second Avenue	1275'	8"	3
Dunton Road	234'	6"	1
Clark Terrace	242'	6"	1
New Hampshire/Rand/Garvin Road	2100'	8"	4
Cristo/Vermont Road	700'	8"	2
Amherst Road	1500'	8"	2
Henry L. Drive	600'	8"	2
Lynch Road	268'	8"	1
Buckingham Road	450'	8"	1
Allgrove Estates	900'	8"	3
Cross country for new water tank	3,100'	12"/16"	1
Total	17,327'		

Total water mains installed during 1989 - 17,327' or 3.14 miles
There have been 41 new hydrant added to the system

THE COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENVIRONMENTAL PROTECTION

WATER SUPPLY ANALYSIS (mg/l)

PWS ID 3342000

EL 6/6/90

CITY/TOWN Wilmington
COLLECTOR H. Dailey, George

SOURCE A Tub Wells - PS Tap - Browns Crossing 342-01G
SOURCE B GP Well - Chestnut St. 342-03G
SOURCE C GP Well - Town Park 342-04G
SOURCE D GP Well - Shawsheen Ave. 342-05G
SOURCE E GP Well - Butter's Row 342-07g

	A	B	C	D	E
SAMPLE NO.	586195	586196	586197	586198	586199
DATE OF COLLECTION	05/30/90	05/30/90	05/30/90	05/30/90	05/30/90
DATE OF RECEIPT	05/30/90	05/30/90	05/30/90	05/30/90	05/30/90
TURBIDITY	0.4	0.7	3.7	0.2	5.8
SEDIMENT	1	1	1	1	0
COLOR	5	35	35	15	60
ODOR	0	D1	0	0	D1
pH	6.1	6.1	6.1	6.1	6.3
ALKALINITY-TOTAL (CaC03)	20	24	33	31	37
PHTH ALKALINITY					
HARDNESS (CaC03)	64	43	74	58	85
CALCIUM (Ca)	19	13	23	17	25
MAGNESIUM (Mg)	3.9	2.7	4.0	3.9	5.6
SODIUM (Na)	48	26	35	22	49
POTASSIUM (K)	2.8	2.0	2.9	2.5	4.1
IRON (Fe)	0.35	0.25	3.5	0.25	4.9
MANGANESE (Mn)	0.59	0.31	0.57	0.29	0.57
SULFATE (S04)	14	20	29	22	43
CHLORIDE (Cl)	105	44	65	34	70
SPEC. COND. (micromhos/cm)	408	239	362	241	402
NITROGEN (AMMONIA)	0.07	0.13	0.30	0.03	1.49
NITROGEN (NITRATE)	1.27	0.16	0.42	1.87	0.03
NITROGEN (NITRITE)	<0.002	0.04	0.012	0.006	0.008
COPPER (Cu)	0.04	0.07	0.03	<0.03	<0.03

REMARKS:

THE COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENVIRONMENTAL PROTECTION

WATER SUPPLY ANALYSIS (mg/l)

PWS ID 3342000

6/4/90

CITY/TOWN Wilmington
COLLECTOR H. Dailey, G
C. Preble

SOURCE A GP Well - Salem St. 342-08G
SOURCE B GP Well - #2 Butter's Row 342-09G
SOURCE C E.H. Sargent W.T.P. Finished 342-09G
SOURCE D
SOURCE E

	A	B	C	D	E
SAMPLE NO.	586201	586202	586203		
DATE OF COLLECTION	05/30/90	05/30/90	05/30/90		
DATE OF RECEIPT	05/30/90	05/30/90	05/30/90		
TURBIDITY	2.6	5.6	0.1		
SEDIMENT	0	0	0		
COLOR	35	25	0		
ODOR	0	0	Cc1		
pH	6.4	6.3	7.2		
ALKALINITY-TOTAL (CaC03)	27	33	23		
PHTH ALKALINITY					
HARDNESS (CaC03)	59	70	81		
CALCIUM (Ca)	18	21	26		
MAGNESIUM (Mg)	3.4	4.5	4.0		
SODIUM (Na)	36	30	48		
POTASSIUM (K)	2.7	3.1	3.1		
IRON (Fe)	2.3	5.6	0.08		
MANGANESE (Mn)	0.72	0.26	<0.03		
SULFATE (S04)	17	32	24		
CHLORIDE (Cl)	68	55	90		
SPEC. COND. (micromhos/cm)	313	341	408		
NITROGEN (AMMONIA)	0.10	0.25	<0.2		
NITROGEN (NITRATE)	0.08	0.29	0.95		
NITROGEN (NITRITE)	0.008	0.008	<0.002		
COPPER (Cu)	<0.03	<0.03	<0.03		

REMARKS:

28

Regular

THE COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERING
WATER SUPPLY ANALYSIS (mg/ per liter)

Wilmington

COLLECTOR J. Viera

SOURCE A Tub. Wells, PS Tap - 342-01G
SOURCE B G.P. Well, Chestnut - 342-03G
SOURCE C " " " Town Park - 342-04G
SOURCE D " " " Shawsheen Ave. - 342-07G
SOURCE E " " " Butters Row #1 - 342-08G
SOURCE F " " " Salem St.

Feb. 1989

	A	B	C	D	E	F
SAMPLE NO.	582236	237	238	239	240	241
DATE OF COLLECTION	2/13/89					
DATE OF RECEIPT	2/13/89					
TURBIDITY	3.5	0.5	7.3	0.5	4.0	5.7
SEDIMENT	0	0	0	0	1	0
COLOR	15	20	20	15	40	30
ODOR	0	0	0	0	0	0
pH	6.0	6.0	6.2	6.1	6.3	6.3
ALKALINITY-TOTAL (CaCO3)	25	24	31	28	61	39
LEAD (mg/l)	<0.002	<0.002	0.009	0.003	<0.002	0.003
HARDNESS (CaCO3)	66	67	98	53	184	66
CALCIUM (Ca)	19.	20.	32.	15.	54.	[illegible]
MAGNESIUM (Mg)	4.3	4.2	4.4	3.6	12.	[illegible]
SODIUM (Na)	50.	41.	54.	20.	95.	38.
POTASSIUM (K)	2.6	2.6	2.8	2.3	6.0	2.5
IRON (Fe)	.49	.69	6.6	.38	7.3	2.6
MANGANESE (Mn)	.54	.34	.42	.33	1.3	[illegible]
SULFATE (SO4)	16	34	27	24	100	20
CHLORIDE (Cl)	95	67	105	31	125	70
SPEC. COND. (micromhos/cm)	400	338	466	219	845	330
NITROGEN (AMMONIA)	0.14	0.19	0.08	0.09	3.2	0.13
NITROGEN (NITRATE)	1.0	0.2	0.5	0.7	<0.1	0.1
NITROGEN (NITRITE)	<0.002	0.002	0.008	<0.002	0.010	0.003
COPPER (Cu)	<.03	<.03	.13	.11	0.3	<.03

1985

Water Department

PUMPING STATISTICS

WATER SUPPLY	1981	1982	1983	1984	1985
Maximum Gallons Per Day	4,218,000	4,450,000	4,326,500	4,228,700	4,193,300
Maximum Gallons Per Week	24,887,000	26,692,700	26,660,900	26,093,500	24,598,300
Maximum Gallons Per Month	100,441,000	101,011,700	104,475,400	100,396,500	101,415,100
Average Gallons Per Day	2,901,976	3,772,883	2,980,879	2,780,674	3,024,474
Average Gallons Per Month	88,268,441	92,488,167	90,668,408	84,578,825	91,994,400
Total Gallons Per Year	1,059,221,300	1,108,858,100	1,088,020,900	1,014,945,900	1,103,932,800
Annual Rainfall	42.82"	46.28"	57.33"	47.61"	36.38"

CONSUMPTION STATISTICS - GALLONS

Residential Use*	352,998,750	363,966,930	427,627,545	413,005,845	408,518,662
Percent of Total	43.0%	44.3%	49.5%	50.6%	46.1%
Industrial Use	466,973,085	456,183,090	435,669,405	402,034,245	477,200,640
Percent of Total	56.9%	55.6%	50.5%	49.3%	53.8%
Total Water Metered	819,971,835	820,150,020	863,296,950	815,040,090	885,719,302
Percent of Water Pumped**	77.4%	73.9%	79.3%	81%	80.2%

*Residential use includes small commercial users, that is, all water passing through 5/8" meters only.

**The difference between the water pumped and the water metered, 218,213,498 gallons in 1985, represents water used for flushing of water mains, for fires and other hydrant uses, and water lost due to breaks and leakage throughout the system.

The Water Treatment Plant supplied approximately 50% of the total water pumped.

WATER DISTRIBUTION SYSTEM

The following new mains were constructed during 1985:

Street	Length	Size	Hydrants
Ballardvale Street	2,080'	12"	5
Research Drive	740'	12"	1

The following new mains were constructed during 1985: (continued)

Street	Length	Size	Hydrants
Flagstaff Road	650'	8"	2
Garden Avenue Ext.	252'	6"	1
McGrane Road	360'	6"	1
Coral Street	350'	6"	1
Cobalt Street	270'	8"	1
Christine Drive	90'	6"	Hydrant Relocated
Kajin Way	460'	8"	1
Kajin Way	20'	6"	
Cary Street	40'	6"	
Crescent Street	190'	6"	
Broad Street	212'	8"	1
Boyle Street	600'	8"	1
Albany Street	550'	8"	1
Fourth Street	550'	8"	1
Lorin Drive	520'	8"	2
Tomahawk Drive	600'	8"	2
Fairfield Road	175'	6"	1
Grand Street	140'	6"	1
Jacobs Street	90'	6"	1
	8,939		24

WATER

The major activity was the initiation of the North Wilmington Water Treatment Plant. The Annual Town Meeting approved $6.4 million dollars for the construction of a treatment facility for the Salem Street well, Barrows wellfield and the Brown's Crossing wellfield. The plant will be built on the site of the Barrows Pumping Station. The treatment process will be similar to the Butter's Row Treatment Plant. Design of the facility was started by Weston and Sampson, Engineers.

Due to a reduction in pumping capacity, it was necessary to clean and redevelop three wells.

Water was supplied to Tewksbury on an emergency basis for one month.

The Board was represented on a Regional Planning Group with Reading and North Reading. This group will be working jointly to protect the groundwater, which is so important to all three towns.

Arthur Smith worked with the Task Force that established new regulations regarding underground storage tanks designed to protect the groundwater.

SEWER

The procedure for establishing a monitoring system of industrial discharges to the sewer was initiated. This program will be implemented in 1986 and is designed to protect the sewer pipes from corrosive liquids that can destroy them. Because of the deterioration of a portion of the Eames Street sewer it was necessary to reconstruct the portion under the railroad. The work was financed by a court settlement against the alleged polluter.

The Board worked with the Wilmington Housing Authority on the design of the sewer on Cedar Street to service the expansion of the Housing for the Elderly on Deming Way.

The construction of the Ballardvale Street sewer began, financed by a consortium of firms in the area.

The Board held discussions with firms interested in extending the sewer on Woburn Street.

Our assessment from the Massachusetts Water Resources Authority (MDC) increased by 78%. Additional increases can be expected.

Water Department

1986

WATER
The design of the North Wilmington Water Treatment was completed. The plans and specifications were approved by the Department of Environmental Quality Engineering. The project will be bid early in 1987. In spite of a State Grant, the financial impact of the debt service will require an increase in water rates in 1987.

A representative of the Board continued participation with the Regional Planning Group with Reading and North Reading.

An application was submitted to the Department of Environmental Quality Engineering for funding the replacement of water mains in North Wilmington.

The Chestnut Street well was cleaned and redeveloped to increase its capacity.

The Water Department Rules and Regulations were revised and updated. In addition, the Special Water Department Charges were increased.

SEWER
The Massachusetts Water Resources Authority sewer assessment increased 43% to $255,000.

Our consultants began updating our Sewer Master Plan.

The industrial discharge monitoring program was initiated. Approximately 40 industries will be tested under this program to verify that they are meeting their discharge permits.

The construction of the Ballardvale Street sewer was completed, financed entirely by private industry.

The contract for the construction of the Cedar Street sewer was signed. This sewer will tie Deming Way Housing for the Elderly into the town's sewer system.

Two (2) applications (Project Information Forms) were submitted to the Division of Water Pollution Control for funding sewer extensions.

The license of one septage hauler to use the septage dumping station was suspended for violation of Sewer Department regulations.

IN APPRECIATION
After 31 years of service to the Town of Wilmington, our Clerk of the Water and Sewer Department, Sylvia L. Bowman, retired this fall. We wish her a long and happy retirement.

PUMPING STATISTICS

WATER SUPPLY	1982	1983	1984	1985	1986
Maximum Gallons Per Day	4,450,000	4,326,500	4,228,700	4,193,300	5,130,700
Maximum Gallons Per Week	26,692,700	26,660,900	26,093,500	24,598,300	28,474,500
Maximum Gallons Per Month	101,011,700	104,475,400	100,396,500	101,415,100	110,876,900
Average Gallons Per Day	3,772,883	2,980,879	2,780,674	3,024,474	2,966,701
Average Gallons Per Month	92,488,167	90,668,408	84,578,825	91,994,400	90,320,492
Total Gallons Per Year	1,108,858,100	1,088,020,900	1,014,945,900	1,103,932,800	1,082,845,900

al Rainfall	46.28"	57.33"	47.61"	36.38"	41.94"

CONSUMPTION STATISTICS - GALLONS

sidential Use*	363,966,930	427,627,545	413,005,845	408,518,662	411,814,446
rcent of Total	44.3%	49.5%	50.6%	46.1%	41.3%
dustrial Use	456,183,090	435,669,405	402,034,245	477,200,640	469,455,823
rcent of Total	55.6%	50.5%	49.3%	53.8%	58.7%
tal Water Metered	820,150,020	863,296,950	815,040,090	885,719,302	881,270,269
rcent of Water Pumped**	73.9%	79.3%	81%	80.2%	87.54%

*Residential use includes small commercial users, that is, all water passing through 5/8" meters.

**The difference between the water pumped and the water metered, 217,413,631 gallons in 1986, represents water used for flushing of water mains, for fires street sweeping and other hydrant uses, and water lost due to main breaks.

The Water Treatment Plant supplied approximately 63.72% of the total water pumped.

WATER DISTRIBUTION SYSTEM

The following new mains were constructed during 1986:

Street	Length	Size	Hydrants
Pineview Road	140'	6"	
Ballardvale Street	46'	6"	
Ballardvale Street	40'	8"	
Fox Run Drive	970'	8"	3
Bailey Road	505'	8"	1
Fairmont Avenue	233'	6"	
Gloria Way	848'	8"	2
Wisser Street	173'	6"	
Morton Road	18'	6"	
St. Paul Street	265'	6"	1
Garden Avenue	94'	6"	
Everett Avenue	425'	8"	1
Marjorie Road	275'	6"	1
Allston Avenue	240'	6"	
Lloyd Road	100'	6"	1
Fifth Avenue	200'	8"	1
Reno Road	400'	8"	1
Gorham Street	600'	8"	1
Chelsea Street	44'	6"	
Norfolk Avenue	185'	6"	
Newbern Avenue	300'	6"	1
Plymouth Avenue	715'	6"	2
Lee Avenue	450'	6"	1
Perry Avenue	20'	6"	
Ohio Street	1150'	8"	3
Cobalt Street	200	6"	1
Winston Avenue	450'	6"	1
Miles Street	250'	8"	1
Jefferson Road	600'	8"	
Research Drive	900'	12"	
Ash Street	300'	6"	
Melrose Avenue	100'	6"	
	11,236'		23

6"	4,348'
8"	5,988'
12"	900'

Hydrants relocated 1986 - 2 Woburn Street and Keirnan Avenue.

1987

Water & Sewer Department

WATER
Bids were received for the Edmund H. Sargent Water Treatement Plant in North Wilmington. The low bid was $4.9 million. Bids for the connecting water mains will be received in 1988. The State will be providing the Town with a grant of approximately $2.8 million. A Ground Breaking Ceremony was held on June 6, 1987. It is expected that the plant will be put into service in early 1989.

An aquifer study was initiated to define the Town's aquifer and the recharge areas around our wells.

Inspections were made on our two existing standpipes. Maintenance work will be needed at the Nassau Avenue tank in 1988.

An engineer was hired to undertake a "Water Master Plan Study". In addition, we authorized the design of a new 3 million gallon storage tank to be located in the Town Forest in North Wilmington.

The granular activated carbon at the Butters Row Water Treatment Plant was replaced at a cost of $41,000.

Water rates were increased on July 1, 1987 to finance the bond payments for the new water treatment plant. This was the first rate increase since 1979. Future rate increases can be expected for future capital expenditures as well as increased operating costs.

New regulations were adopted requiring the submission of a Water Impact Report for any development that exceeds 40,009 gallon per day of water usage. This report will be used to determine the effect the development will have on the Town's water system.

Automatic underground sprinkler irrigation systems were banned for all new construction.

Unpaid water and sewer bills continue to be a problem, averaging $60,000 annually. It was voted to develop a water service "interruption" policy for delinquent users. The proposed policy is being reviewed by Town Counsel.

Commissioner Maurice "Dice" O'Neil passed away on April 19, 1987. In addition to serving on our Board, he was also a long-time employee of the Water Department, before his retirement in 1981. James A. Ring was appointed by the Town Manager to fill his unexpired term.

SEWER
Our updated Sewer Master Plan was completed.

The sewer extension to service the Deming Way Housing Project was put into operation.

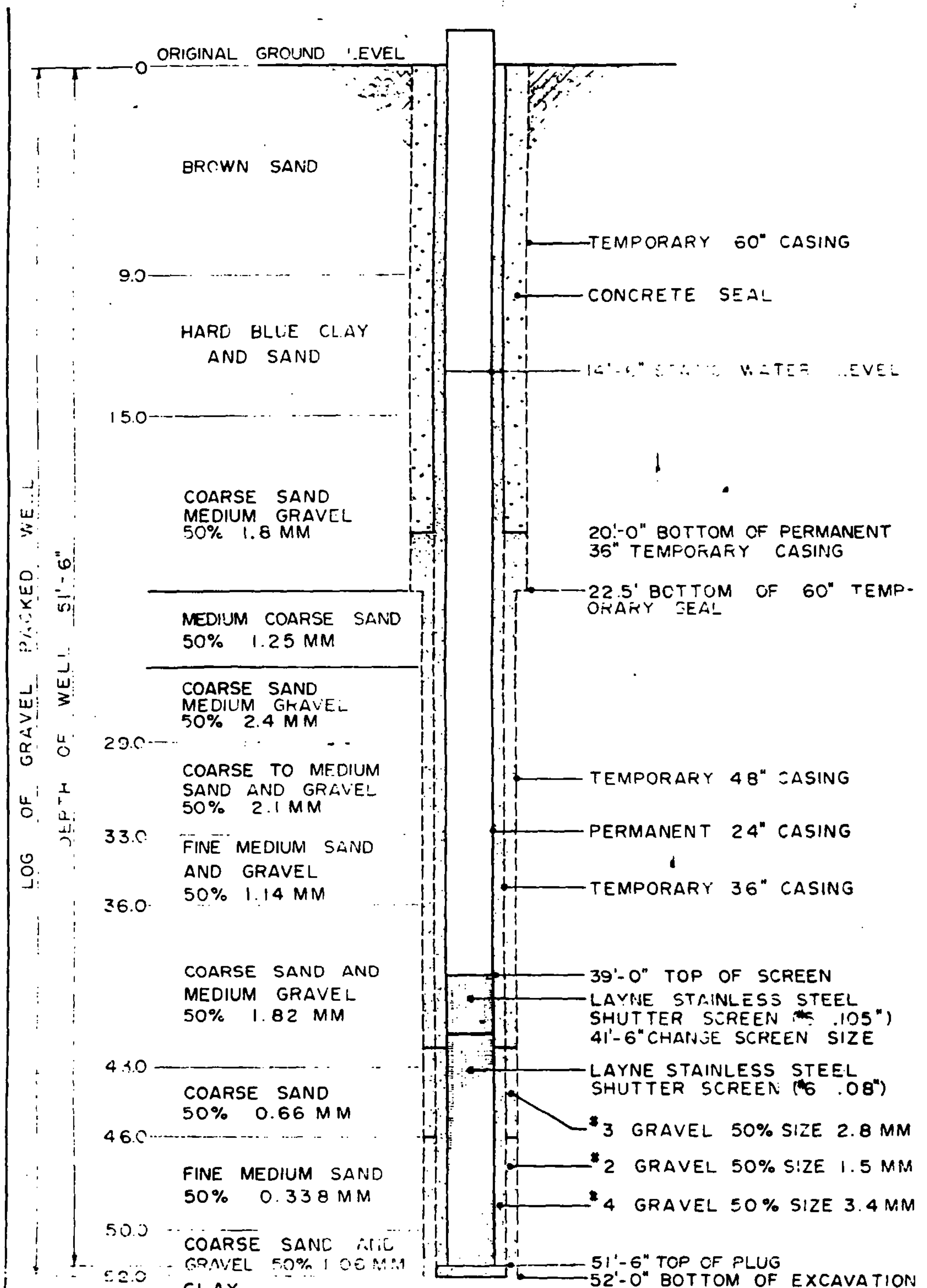
Sewer rates were increased, July 1, 1987 in conjunction with the water rate increase.

Our sewer assessment from the Massachusetts Water Resources Authority continues to increase. This year it was $255,872.00

PUMPING STATISTICS

WATER SUPPLY	1983	1984	1985	1986	1987
Maximum Gallons Per Day	4,326,500	4,228,700	4,193,300	5,130,700	4,518,100
Maximum Gallons Per Week	26,660,900	26,093,500	24,598,300	28,474,500	29,735,500
Maximum Gallons Per Month	104,475,400	100,396,500	101,415,100	110,876,900	124,240,900
Average Gallons Per Day	2,980,879	2,780,674	3,024,474	2,966,701	3,192,664
Average Gallons Per Month	90,668,408	84,578,825	91,994,400	90,320,492	95,779,920

Butters Row Well #1
700GPM



SCALE: 1/4" = 1'-0"

DIAGRAM OF GRAVEL PACKED WELL NO. 2

BUTTERS ROW #1

WILMINGTON, MASS.

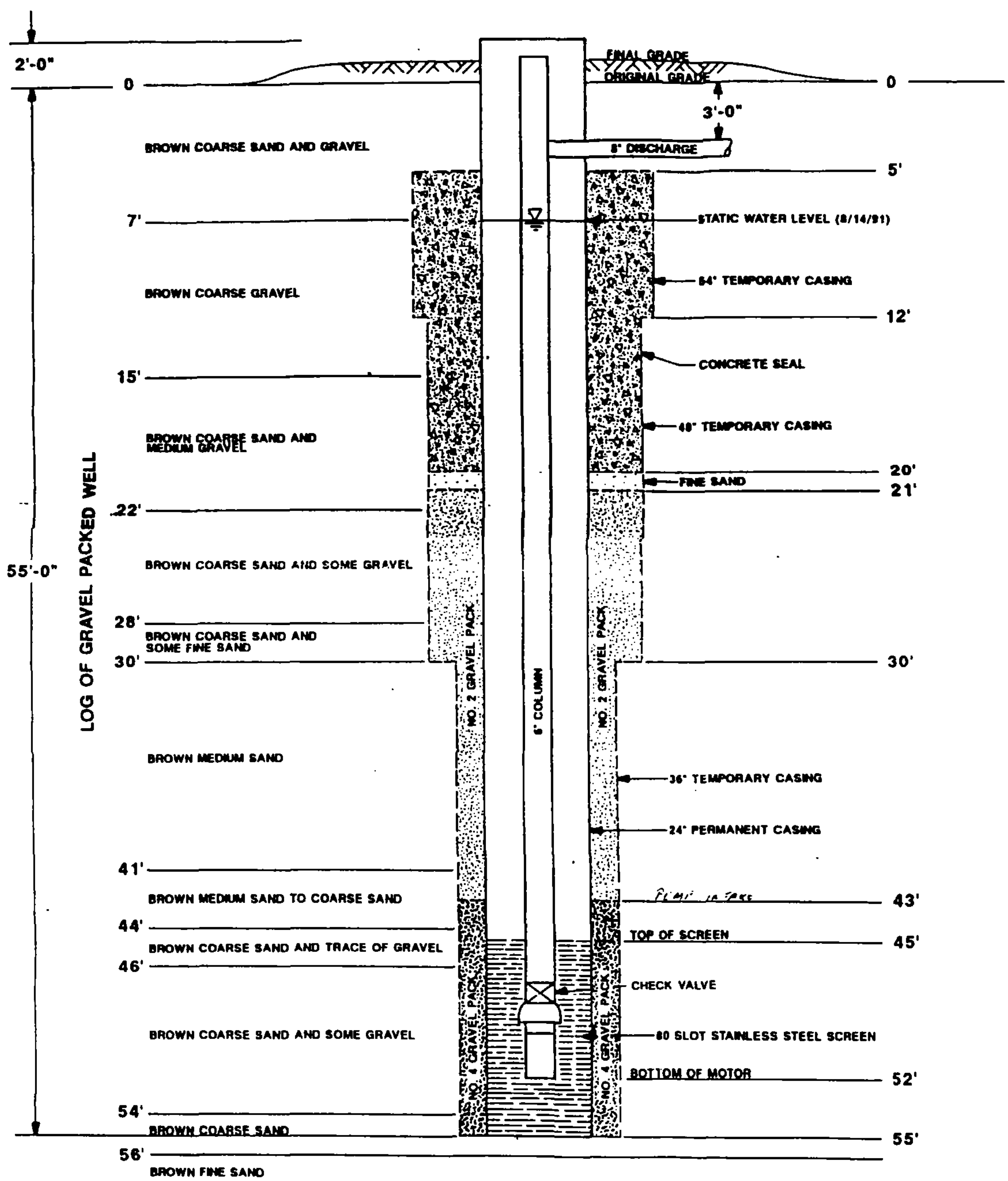
WHITMAN & HOWARD INC., ENGINEERS and ARCHITECTS
89 BROAD STREET BOSTON, MASSACHUSETTS

OCTOBER, 1971

PUMP : SINGLE STAGE 500 GPM @ 104' TDH
SPECIFIC CAPACITY : 50 GPM/FT
AUGUST, 1991 (AT END OF 48 HR TEST)

MOTOR : 20 HP; 6"; 460 VOLT; 3 PHASE

PITLESS ADAPTER : MODEL NO. MB HD
WITH FLOW METER



GRAVEL PACKED WELL 1A
CHESTNUT STREET
WILMINGTON, MA
AUGUST, 1991

Dufresne-Henry, Inc.
Westford, Ma

SCALE : HORIZ. 1/2" = 1'-0"
VERT. 3/16" = 1'-0"

Average Gallons Per Month	84,578,825	91,994,400	90,320,492	95,779,920	98,712,563
Total Gallons Per Year	1,014,945,900	1,103,932,800	1,082,845,900	1,185,567,065	1,184,550,563*

*Includes water purchased from other systems

Annual Rainfall	47.61"	36.38"	41.94"	38.41"	36.10"

CONSUMPTION STATISTICS - GALLONS

Residential Use*	413,005,845	408,518,662	411,814,446	474,675,803	432,331,418
Percent of Total	50.6%	46.1%	41.3%	40.71%	47.64%
Industrial Use	402,034,245	477,200,640	469,455,823	631,254,953	470,317,313
Percent of Total	49.3%	53.8%	58.7%	59.29%	51.83%
Total Water Metered	815,040,090	885,719,302	881,270,269	1,109,869,081	907,415,379
Percent of Water Pumped**	81%	80.2%	87.54%	95.19%	76.60%

*Residential use includes small commercial users, that is, all water passing through 5/8" meters.

**The difference between the water pumped and the water metered, 274,135,372 gallons in 1988, represents water used for flushing of water mains, for fires street sweeping and other hydrant uses, and water lost due to main breaks.

The Butters Row Water Treatment Plant supplied approximately 49.64% of the total water pumped.

WATER DISTRIBUTION SYSTEM

The following new mains were constructed during 1988:

Street	Amount	Size	Hydrants
Research Drive	360'	12"	0
Ohio Street	135'	8"	1
Tracey Circle	700'	8"	2
Ash Street	600'	6"	1
Quail Run	550'	8"	1
Earles Row	1900'	8"	3
Allenhurst Drive	1200'	8"	3
Mather Street	200'	8"	1
Winston Avenue	300'	6"	1
Fenway Road	225'	8"	0
Rollins Road	225'	8"	0
Blanchard Road	229'	8"	1
	6624'	900'-6" Main	14
		5364'-8" Main	
		360'-12" Main	
		6624' TOTAL MAINS	

New water mains constructed in conjunction with E. H. Sargent Water Treatment Plant.

Salem Street (Route 62)	950'	8"	2
Woburn Street to WTP I/N Easement	1860'	16"	0
Woburn Street to Easement	5660'	16"	4
Brown's Crossing P.S. to Route 62	1496'	12"	2
	9966'	950'-8" Main	14
		1496'-12" Main	
		7520'-16" Main	
		9966' TOTAL MAINS	

Total Water Mains Installed during 1988 - 16,590' or 3.14 miles

1989

Water & Sewer Department

WATER

The Edmund H. Sargent Water Treatment Plant was put into service on May 2, 1989, with all state approvals being met.

An open house was held on September 16, 1989. The open house was attended by many neighborhood residents and Water Department personnel.

The contracts for the 3.0 million gallon water storage tank and connecting water mains were awarded.

Except for landscaping the tank is complete and was put into full service December, 1989.

The Water Department has obtained the services of a consulting firm to study and prepare "Aquifer Protection Zoning By-Laws" to be adopted at the Annual Town Meeting (1990).

Many "Water Impact Reports" were reviewed for proposed sub-divisions.

Unpaid water and sewer bills for 1988, in the amount of $52,941.02, were committed as liens to the Tax Collector.

SEWER

The Northeast Sewer Interceptor design is still ongoing. Survey work on private property is being done where access permission has been obtained.

Nine hundred feet of sewer interceptor has been cleaned in the South Main Street area.

Approximately 2,200 feet of sewer is to be constructed in Main Street, from the junction of Route 38 and Route 129 to Cross Street. Construction is expected to start early 1990.

A sewer rate increase was reflected in the October, 1989 sewer billing. Most of the sewer rate increase was due to the sewer assessment charges from the Massachusetts Water Resources Authority. Charges for FY-1990 are $660,581.00.

PUMPING STATISTICS

WATER SUPPLY	1984	1985	1986	1987	1988	1989
Maximum Gallons Per Day	4,228,700	4,193,300	5,130,700	4,518,100	4,912,000	4,064,500
Maximum Gallons Per Week	26,093,500	24,598,300	28,474,500	29,735,500	29,811,200	22,565,700
Maximum Gallons Per Month	100,396,500	101,415,100	110,876,900	124,240,900	120,030,100	97,243,800
Average Gallons Per Day	2,780,674	3,024,474	2,966,701	3,192,664	3,245,345	2,823,110
Average Gallons Per Month	84,578,825	91,994,400	90,320,492	95,779,920	98,712,563	85,869,600
Total Gallons Per Year	1,014,945,900	1,103,932,800	1,082,845,900	1,185,567,065	1,184,550,563*	1,030,435,200*
*Includes water purchased from other systems						
Annual Rainfall	47.61"	36.38"	41.94"	38.41"	36.10"	42.66"

CONSUMPTION STATISTICS - GALLONS

	1984	1985	1986	1987	1988	1989
Residential Use*	413,005,845	408,518,662	411,814,446	474,675,803	432,331,418	403,228,522
Percent of Total	50.6%	46.1%	41.3%	40.71%	47.64%	39%
Industrial Use	402,034,245	477,200,640	469,455,823	631,254,953	470,317,313	457,822,530
Percent of Total	49.3%	53.8%	58.7%	59.29%	51.83%	44%
Total Water Metered	815,040,090	885,719,302	881,270,269	1,109,869,081	907,415,379	857,301,052

Total Gallons Per Year	1,088,020,900	1,014,945,900	1,103,932,800	1,082,845,900	1,185,567,065*

*Includes water purchased from other systems

Annual Rainfall	57.33"	47.61"	36.38"	41.94"	38.41"

CONSUMPTION STATISTICS - GALLONS

Residential Use*	427,627,545	413,005,845	408,518,662	411,814,446	474,675,803
Percent of Total	49.5%	50.6%	46.1%	41.3%	40.71%
Industrial Use	435,669,405	402,034,245	477,200,640	469,455,823	631,254,953
Percent of Total	50.5%	49.3%	53.8%	58.7%	59.29%
Total Water Metered	863,296,950	815,040,090	885,719,302	881,270,269	1,109,869,081
Percent of Water Pumped**	79.3%	81%	80.2%	87.54%	95.19%

*Residential use includes small commercial users, that is, all water passing through 5/8" meters.

**The difference between the water pumped and the water metered, 75,700,984 gallons in 1987, represents water used for flushing of water mains, for fires street sweeping and other hydrant uses, and water lost due to main breaks.

The Water Treatment Plant supplied approximately 46.12% of the total water pumped.

WATER DISTRIBUTION SYSTEM

The following new mains were constructed during 1987:

Street	Length	Size	Hydrants
Research Road	380'	12"	
Fourth Avenue	150'	6"	1
Fay Street	600'	6"	1
Silverhurst Avenue	54'	6"	
Lee Street	150'	6"	1
Appletree Lane	1000'	8"	2
Cobalt Street	228'	6"	
Research Drive	1200'	12"	1 Standpipe Line
Research Drive	900'	12"	3
Patches Pond Lane	1200'	8"	4
Towpath Drive	1350'	8"	3
Roosevelt Road	350'	8"	1
Dewey Avenue	200'	6"	1
Jefferson Road	400'	8"	1
Albany Street	173'	8"	
Factory Road	1000'	6"	2
Blanchard Road	500'	8"	1
Crescent & Fall Street	200'	6"	1
Dexter Street	180'	8"	
Valyn Lane	600'	8"	2
Day Street	450'	6"	1
	11,265'		26

6"	3,032'
8"	5,753'
12"	2,480'
TOTAL	11,265

1988

Water & Sewer Department

WATER

The Edmund H. Sargent Water Treatment Plant is nearing completion and expects to be in service early 1989. The water main contract relative to the new Water Treatment Plant was awarded to Tornare Construction Corporation and construction was completed this fall.except for final paving to be completed in the spring of 1989.

The April 1988 Annual Town Meeting authorized the expenditure of 1.4 million dollars for a 3.0 million gallon water storage tank and connecting water mains. The storage tank is to be located on Town Forest land in North Wilmington.

A "Master Water Plan" is being designed to plan for future water needs into the year 2010.

Water Impact Studies were submitted by all developers for proposed subdivisions or commercial and industrial developments using in excess of 4,000 gallons of water per day. These studies were reviewed to determine the impact of the proposed development on the water requirements of the town.

The Water Department purchased the former "Cranberry Bog" property on Shawsheen Avenue. The land purchased was approximately 60+ acres for $95,000. This property will allow for future well field development and groundwater protection.

A water rate increase was reflected in the October 1988 water billing. This increase was necessary to cover increased operating costs and bonding for the new water storage tank and connecting water mains.

Unpaid water and sewer charges for 1987, in the amount of $51,168.30, were committed as liens to the Tax Collector.

SEWER

The April 1988 Annual Town Meeting authorized the expenditure of $450,000 for engineering services to design the North/East sewer interceptor. This sewer design should be ready for review in the spring of 1989.

Sewer Master Plan has been updated to conform with zoning changes.

The Jacobs Street sewer has been completed and approved for sewer connections by the residents.

A sewer rate increase was reflected in the October 1988 sewer billing. Most of the sewer rate increase was due to the sewer assessment charges from the Massachusetts Water Resources Authority. Charges for FY-89 are $389,353.

The Town of Wilmington has been notified by the Massachusetts D.E.Q.E. that all grant monies awarded to the town are currently on "hold" but the State will honor all grants when the monies are available in the State.

It was with many regrets that the Water & Sewer Commissioners accepted the resignations of George R. Allan, Chairman of the Board. George had been a dedicated member of the Board of Water & Sewer Commissioners for 13 1/2 years prior to his resignation October 15, 1988. The Commissioners would like to extend their thanks to George, on behalf of the Board and the Town for his many years of dedicated service, his expertise will be greatly missed. The Town Manager appointed Noel Baratta to fill the vacancy on the Board and Arthur R. Smith, Jr., was elected Chairman of the Board.

PUMPING STATISTICS

WATER SUPPLY	1984	1985	1986	1987	1988
Maximum Gallons Per Day	4,228,700	4,193,300	5,130,700	4,518,100	4,912,000
Maximum Gallons Per Week	26,093,500	24,598,300	28,474,500	29,735,500	29,811,200
Maximum Gallons Per Month	100,396,500	101,415,100	110,876,900	124,240,900	120,030,100
Average Gallons Per Day	2,780,674	3,024,474	2,966,701	3,192,664	3,245,345

Regular

THE COMMONWEALTH OF MASSACHUSETTS

DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERING

WATER SUPPLY ANALYSIS (mg/ per liter)

Wilmington

COLLECTOR Viera

MARCH 87

SOURCE A Tub. Wells, Brown's Crossing - 342-01G
SOURCE B G.P. Well, Chestnut St. - 342-03G
SOURCE C " " " Town Park Well - 342-04G
SOURCE D " " " Shawsheen Ave - 342-05G
SOURCE E " " " Butters Row - 2 - 342-07G
SOURCE F " " " Salem St. - 342-08G

	A	B	C	D	E	F
SAMPLE NO.	576393	394	395	396	397	398
DATE OF COLLECTION	3/24/87					
DATE OF RECEIPT	3/24/87					
TURBIDITY	0.6	2.6	8.5	0.3	3.9	5.0
SEDIMENT	0	0	0	0	0	0
COLOR	5	30	20	10	27	40
ODOR	0	0	0	0	0	0
pH	6.1	7.3	6.3	6.2	6.3	6.3
ALKALINITY-TOTAL (CaCO3)	22	43	36	32	36	29
HARDNESS (CaCO3)	65	122	77	53	81	57
CALCIUM (Ca)	19.	39.	24.	15.	24.	17.
MAGNESIUM (Mg)	4.2	5.8	4.2	3.7	5.2	3.3
SODIUM (Na)	47.	45.	50.	18.	30.	26.
POTASSIUM (K)	2.7	3.9	3.1	2.6	3.1	2.3
IRON (Fe)	.23	.33	2.3	.11	6.0	1.8
MANGANESE (Mn)	.31	.06	.47	.23	.24	.56
SULFATE (SO4)	15	80	40	23	45	18
CHLORIDE (Cl)	85	72	76	26	62	50
SPEC. COND. (micromhos/cm)	369	494	406	214	379	289
NITROGEN (AMMONIA)	0.05	0.33	0.26	0.05	0.14	0.09
NITROGEN (NITRATE)	0.9	<0.1	0.5	1.6	0.2	0.1
NITROGEN (NITRITE)	<.002	.003	.005	.006	.007	.006
COPPER (Cu)	<.03	<.03	<.03	.05	<.03	.08

March 1988

Regular

THE COMMONWEALTH OF MASSACHUSETTS

DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERING

WATER SUPPLY ANALYSIS (mg/ per liter)

E JL

Rec'd 5-18-88

Wilmington

COLLECTOR D. Smith

SOURCE A Chestnut St. Well - 342-03G

SOURCE B G.P. Well, Town Park - 343-04G

SOURCE C " " " Shawsheen Ave. - 342-05G

SOURCE D " " " Aldrich Well - 342-06G

SOURCE E " " " Butters Row -

SOURCE F " " " "

A, B, E, F – Raw Supply to WTP

D - OUT of SERVICE

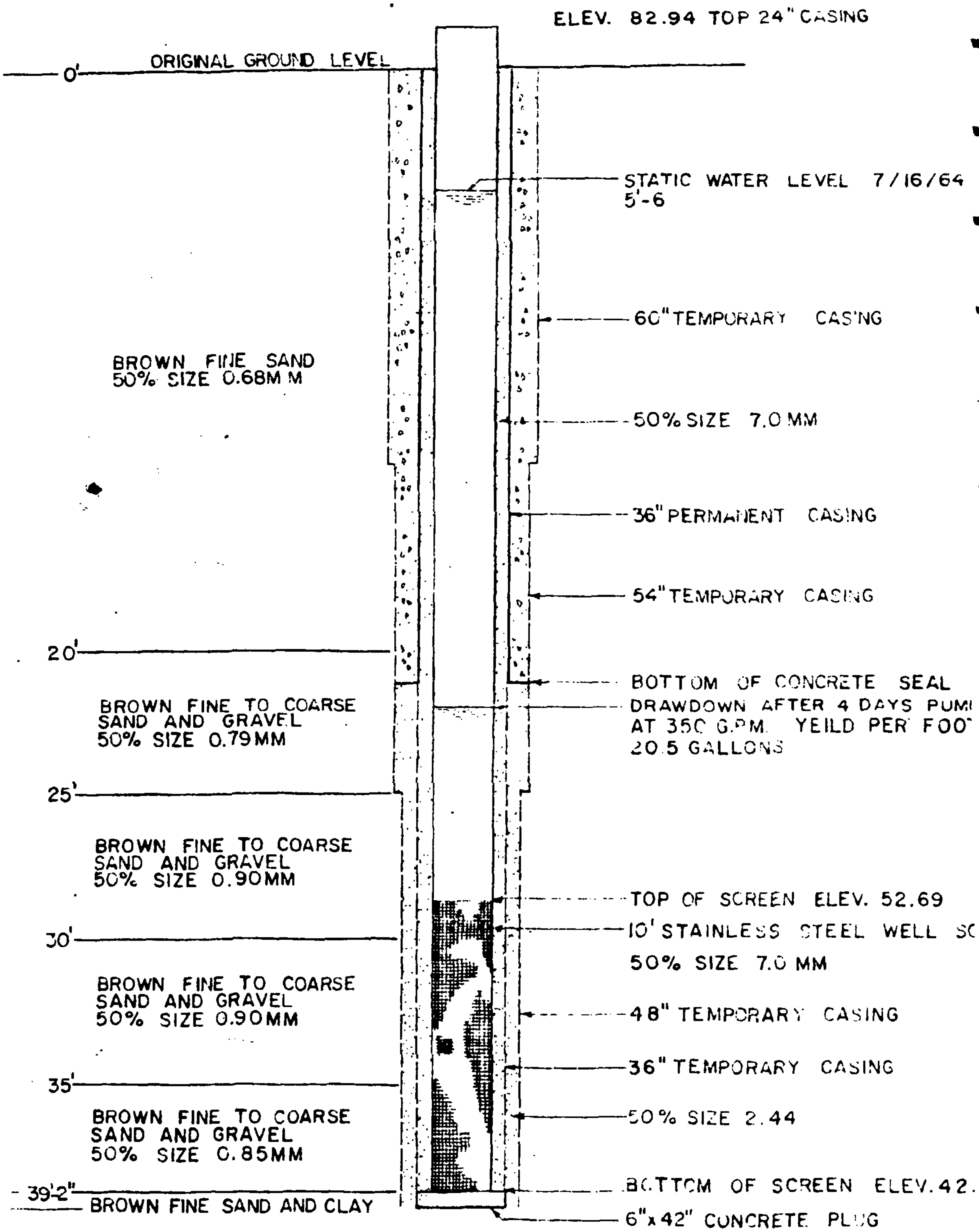
	A	B	C	D	E	F
SAMPLE NO.	579628	629	630	631	632	633
DATE OF COLLECTION	3/25/88					
DATE OF RECEIPT	3/25/88					
TURBIDITY	1.2	5.5	0.6	1.5	5.7	9.6
SEDIMENT	0	0	0	0	0	0
COLOR	35	40	20	10	130	90
ODOR	0	0	0	0	0	0
pH	6.1	6.0	6.1	6.0	6.2	6.1
ALKALINITY-TOTAL ($CaCO_3$)	26	31	24	13	41	32
HARDNESS ($CaCO_3$)	67	67	45	33	135	91
CALCIUM (Ca)	20.	21.	13.	10.	40.	27.
MAGNESIUM (Mg)	4.1	3.5	3.0	2.0	8.6	5.5
SODIUM (Na)	41.	55.	18.	13.	69.	38.
POTASSIUM (K)	3.7	3.2	3.2	1.3	5.0	4.0
IRON (Fe)	.67	1.1	.14	.20	3.4	3.2
MANGANESE (Mn)	.38	.45	.21	.08	.85	.27
SULFATE (SO_4)	33	30	17	16	46	44
CHLORIDE (Cl)	59	85	23	25	110	63
SPEC. COND. (micromhos/cm)	315	396	192	153	574	367
NITROGEN (AMMONIA)	0.12	0.18	0.07	<0.02	1.38	0.14
NITROGEN (NITRATE)	0.2	0.7	0.6	0.5	<0.1	0.3
NITROGEN (NITRITE)	<0.002	0.007	<0.002	<0.002	0.012	0.003
COPPER (Cu)	<.03	<.03	<.03	<.03	<.03	<.03

Chestnut St. Well (Old Well)

Engineer's : Whitman & Howard
Installed : 9/61 Well
Depth of Well : 55' Gravel Packed by Layne Pump
Casing : 24"
Stainless Steel Screen 15'
Pump : Layne Pump 3 stage with 8" column
Rated : 700 GPM
Depth to suction 37'-11"
Air line : 39'
Pump replaced : 3/14/86 3 stage pump, the old columns and shafts were reused, except for one new 5' column above the new 3 stage pump.
Motor H.P. 25 US MOTORS

COMPRESSOR - KELLOGG AMERICAN
MODEL - 211TV

COMPRESSOR TANK - KARCARD INDUSTRIES, INC
W.P. 165
TEMP. 450°
YEAR BUILT 1980



1/4" = 1'-0"

DIAGRAM OF GRAVEL PACKED WELL NO. 5

TOWN PARK

WILMINGTON, MASS.

WHITMAN & HOWARD INC., ENGINEERS and ARCHITECTS
89 BROAD STREET BOSTON, MASSACHUSETTS

JULY 1964

WILMINGTON

Chestnut Street

Log of 8" Well No. 2

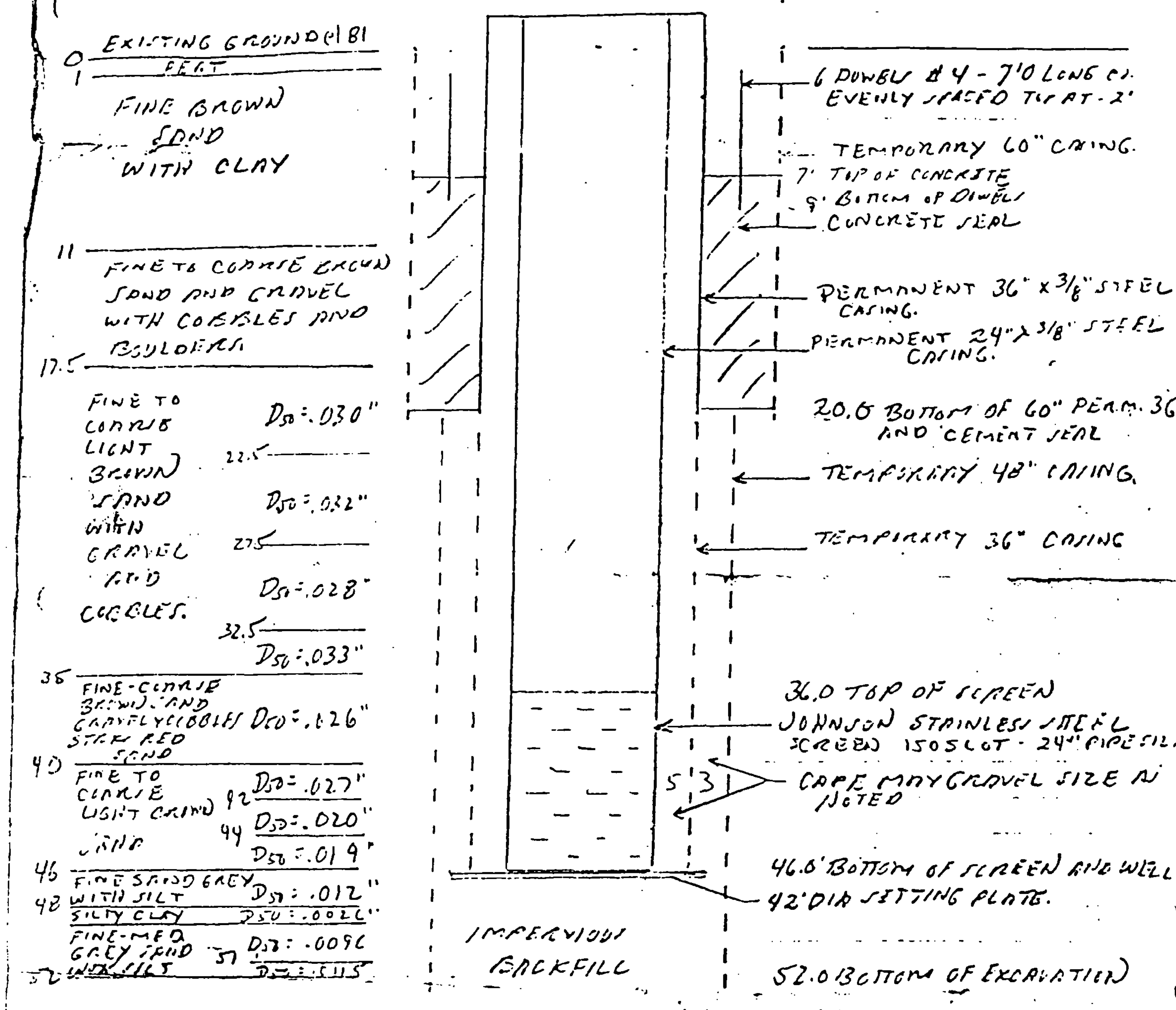
0 - 10' Brown coarse gravel

10' - 22' Brown sand

22' - 46' Brown coarse gravel
Stopped at 46'-0"

Set 80 slot screen at 46'-0"

Pumped 500 g.p.m. with 5' of d.d in 8" well.



NOTES
GRAVEL SIZE D_{50}
#3 = 0.10"
#5 = 0.28"
FURNISH 2 - 2" x 3'0 WITH CAP.

8 yd #5
7 yd #3

TOWN OF WILMINGTON
MASS

PROPOSED WELL COMPLETION
WELL 1-79
Butters Row Well #2

DATE 3/12/79 | SCALE - | SHEET 1

LAYNE NEW ENGLAND CO.
BRANCH OF LAYNE - NEW YORK CO., INC.
ARLINGTON, MASS.

The six remaining municipal well sites consist of individual gravel-packed wel. Their completion dates, depths, and estimated specific capacity are shown in Tab 7.2. In 1981, a treatment plant was built at the Butters Row site. The discharge fro Butters Row, Chestnut Street and Town Park are combined at the Butters Ro Treatment Plant. This treatment plant and the one at the Barrows site are discuss more fully in Section 9.0. The Shawsheen and Aldridge Road wells are n currently connected to a water treatment facility and are not in regular use dı primarily to high iron and manganese concentrations in the ground water.

Table 7.2
WILMINGTON MUNICIPAL WELL DATA

Well	Screen Depth(s)	Date Installed	Specific Capacity
Browns Crossing	37'-72'	1927	ND
Salem Street	29'-39'	1969	53.24
Barrows	30'	1957	ND
Shawsheen Avenue	25'-35'	1965	39.08
Aldrich Road	ND	1966	19.78
Chestnut ~~Street~~	31'-36' 51-44	1960	116.6
Town ~~Park~~	40'	1965	22.5
~~Butlers Row~~ #1	42'-52'	1971	46.3
Butlers Row #2	36'-46'	1979	51.09

ND = No Data

The combined yield of all Wilmington's municipal wells is approximately 1 billion gallons per year. The average yield and design yield for each municipal w site is shown in Table 7.3. The design yield represents the designed pumpi capacity at individual well sites and does not necessarily reflect the long term sa yield of the aquifer.

Because of the favorable geologic conditions for ground water development in t Wilmington area, the municipal wells for the Towns of Reading and Nor Reading are located near the Wilmington Town line. These wells need to considered in any analysis of Wilmington ground water conditions as they dra water from the same aquifer system and the zones of contribution to these wells f largely within the Town of Wilmington. The Reading Wells include: The 100 Ac Wellfield near the main channel of the Ipswich River and two wells along Rev Brook. The North Reading Wells include Lakeside, Route 125, Railroad bed, Cent Street and Stickney Wells. The current pumping status and maximum design yiel for these wells are also listed in Table 7.3. The Reading and North Reading wells a also shown as Figure 7.2.

Table 7.3
MUNICIPAL WELL YIELDS

WILMINGTON

	Maximum Design Yield MGD	Maximum Design Yield GPM	Average Pumping Rate MGD	Average Pumping Rate GPM
Brown's Crossing	1.55	1076	0.9	600
Salem Street	1	700	0.5	350
Barrows	0.9	650	(0.5)*	(350)*
Shawsheen Avenue	0.7	500	(0.6)*	(383)*
Aldrich Road	0.5	350	(0.5)*	(350)*
Chestnut Street	1.4	950	0.5	350
Town Park	0.5	350	0.2	180
Butters Row #1	1.3	900	0.7	450
Butters Row #2	1.4	950	0.9	650
TOTAL	9.3	6426	3.7	2580

Information obtained from Paul Duggan, Wilmington Water & Sewer Department, 3/9/90.

NORTH READING

	Maximum Design Yield MGD	Maximum Design Yield GPM	Average Pumping Rate MGD	Average Pumping Rate GPM
Route 125	0.2	131	—	—
Central Street	0.3	250	0.2	134
Lakeside	0.6	583	0.6	382
Railroad Bed	0.5	312	0.3	188
Stickney	Offline/VOC contamination	—	—	—
TOTAL	1.6	1276	1.1	704

Information obtained from Steve Cassaza, Town of North Reading Engineer, 3/9/90.

READING

	Maximum Design Yield MGD	Maximum Design Yield GPM	Average Pumping Rate MGD	Average Pumping Rate GPM
100-Acre Wellfield				
2	0.9	650		
3	0.4	250		
13	1	700		
15	1.1	750	2.2	1509
66-8	0.7	500		(Combined Yield
B-Line	1.1	750		
Town forest	1.5	1000		
82-20	Offline VOC Contamination	—	—	—
Revay Brook				
1	0.9	600	—	Not in regular use - high sodium levels
2	not used	—	—	
TOTAL	7.6	5200	2.2	1509

Information obtained from Peter Taffi, Reading Water Department, 3/0/90.

COMBINED TOTAL	**18.5**	**12902**	**7.0**	**4793**

*Not currently in use (see Section 7.3)

ND = No Data
MGD = Million Gallons per Day
GPM = Gallons per Minute
NA = Not Available

Table 7.1
WILMINGTON WATER TABLE ELEVATIONS

Well	Well Elevation	Water Depth 11/16/89	Water Elevation 11/16/89	Water Depth 1/18/90	Water Elevation 1/18/90
Aldrich Road					
1	105.43	4.20	101.23	4.36	101.07
2	105.83	4.60	101.23	4.84	100.99
3	107.41	6.20	101.21	6.37	101.03
Barrows Wellfield					
1	75.79	2.40	73.39		75.79
Brown's Crossing					
2	76.91	8.00	68.91	7.99	68.92
Butter's Row					
1	87.81	12.60	75.21	15.31	72.50
2	79.79	5.30	74.49	8.26	71.53
Chestnut St.					
1	84.81	3.65	81.16	4.59	80.22
1A	81.51	3.75	77.76	4.70	76.81
2	81.18	3.25	77.93	4.18	77.00
3	81.26			4.16	77.10
4	82.16			5.63	76.53
Salem St.					
1	76.13	7.40	68.73	9.17	66.96
2	76.71	11.40	65.13	13.17	63.54
Shawsheen Ave.					
1	99.13	4.70	94.43	5.29	93.84
2	97.91	3.50	94.41	3.91	94.00
Town Park					
1	81.33	4.90	76.43	4.24	77.09
Piezometers				1/9/90	1/9/90
PZ-1	75.78			1.62	74.16
PZ-2	78.53			1.57	76.96
PZ-3	79.39			1.40	77.99
PZ-4	82.24			1.41	80.83
PZ-5	97.28			3.41	93.87
PZ-6	90.23			1.85	88.38
PZ-7	76.99			2.93	74.06
PZ-8	74.74			0.75	73.99
PZ-9	98.42			1.75	96.67
PZ-10	107.47			1.39	106.08
PZ-11	99.29			1.22	98.07
PZ-12	84.31			2.45	81.86
PZ-13	84.08			2.91	81.17
PZ-14	111.27			3.30	107.97
PZ-15	81.55			2.63	78.92

NOTE: Water levels measured in feet
Wells and piezometers surveyed to NGVD

Regular

THE COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERING
WATER SUPPLY ANALYSIS (mg/ per liter)

Wilmington

COLLECTOR Vieira

SOURCE A Tub. Wells Brown's Crossing - 342 01G
SOURCE B " " Barrow's - 342-02G — OFF LINE TO WASTE
SOURCE C G.P Well, Chestnut St. - 342-03G
SOURCE D " " " Town Park Well - 342-04G — OFF
SOURCE E " " " Shawsheen Ave. - 342-05G
SOURCE F " " " Butters Row #2 - 343-06G — WATER Treatment PLANT

4-1-86

	A	B	C	D	E	F
SAMPLE NO.	573462	463	464	465	466	467
DATE OF COLLECTION	4/1/86					
DATE OF RECEIPT	4/1/86					
TURBIDITY	0.2	3.0	1.4	3.0	5.1	2.5
SEDIMENT	0	0	0	0	0	0
COLOR	0	10	25	10	27	30
ODOR	0	0	0	0	0	0
pH	6.0	6.3	6.1	6.0	6.0	6.0
ALKALINITY-TOTAL(CaCO3)	20	38	28	26	23	23
HARDNESS(CaCO3)	56	78	55	77	40	68
CALCIUM(Ca)	16.	24.	16.	24.	11.	20.
MAGNESIUM(Mg)	3.9	4.4	3.7	4.2	3.0	4.5
SODIUM(Na)	42.	50.	27.	37.	18.	30.
POTASSIUM (K)	2.0	2.0	1.6	2.0	1.5	2.2
IRON(Fe)	.14	.29	.73	1.4	.30	3.8
MANGANESE(Mn)	.20	.78	.35	.42	.21	.23
SULFATE(SO4)	13	18	29	40	22	47
CHLORIDE(Cl)	78	90	40	67	24	54
SPEC. COND.(micromhos/cm)	330	412	250	357	180	309
NITROGEN(AMMONIA)	0.03	0.06	0.14	0.22	0.06	0.12
NITROGEN(NITRATE)	1.3	0.9	0.1	0.6	1.2	0.2
NITROGEN(NITRITE)	<.002	.005	<.002	<.002	.004	<.002
COPPER(Cu)	<.02	.32	.26	.01	.36	<.02

A

TABLE 2.1

PRODUCTS/RAW MATERIALS/WASTE PRODUCTION PERIODS (1)
WILMINGTON FACILITY

Process	*Raw Materials*	*Product*	*Waste By-Products*	*Process Operation Period*
Opex (Dinitrosopenta-methylenetetramine)	Hexamethylenetetramine Sodium nitrite Hydrochloric acid Ammonia Processing oil	Dinitrosopentamethylenetetramine (solid)	Sodium chloride Sodium nitrate Formaldehyde Ammonium chloride Processing oil	1953 - 1986 (2)
Kempore (Azodicarbonamide)	Hydrazine Urea sulphuric acid Sodium chlorate(3) Sodium bromide (catalyst level)	Azodicarbonamide (solid)	Sodium sulphate Sulphuric acid Urea Sodium chloride Ammonium sulphate Sodium bromide	1956 - 1986 (2)
Hydrazine(4)	Urea Chlorine Sodium hydroxide Sulphuric acid	Hydrazine and Semicarbazide solution	Sodium sulphate Sodium chloride Ammonium sulphate	1963 - 1970
Kempore Dispersions	Azodicarbonamide Dioctyl phthalate	50 percent dispersion of Azodicarbonamide in Dioctyl Phthalate	None	1960 - 1986 (2)
Wytox 312 (trisnonylphenyl phosphite)	Nonyl phenol Phorphorus trichloride	Trisnonylphenyl phosphite (liquid)	None (HCl scrubbed in water)	1965 - 1986 (2)
Actafoam R-3	2-ethylhexoic acid Zinc oxide Dioctyl phthalate Potassium oleate	Liquid Azodicarbonamide activitor	None	1963 - 1986 (2)
Wytox PAP (Alkylated phenol)	Nonyl phenol Dinonyl phenol Formaldehyde	Liquid Alkylated phenol	None	1971 - 1986 (2)

TABLE 2.1

PRODUCTS/RAW MATERIALS/WASTE PRODUCTION PERIODS (1)
WILMINGTON FACILITY

Process	*Raw Materials*	*Product*	*Waste By-Products*	*Process Operation Period*
Nitropore 5 PT (5) (5-Phenyltetrazole)	Benzonitrile Sodium azide Sodium nitrite Ammonium chloride Hydrochloric acid Dimethyl Formamide	5-phenyltetrazole (solid)	Sodium chloride Dimethyl Formamide Sodium nitrate Benzonitrile	1965 - 1975
Nitropore OT (4,4'oxybisbenzenedisulfonyl-hydrazide)	Diphenyl oxide Chlorosulfonic acid Hydrazine Ammonia	4,4'oxybisbenzenedisulfonylhydrazide	Sulphuric acid Ammonium chloride Hydrochloric acid scrubbed in water and solid	1969 - 1986 (2)
Wytox ADP (Dioctyl Diphenylamine)	Diphenylamine Diisobutylene Aluminum chloride Sodium hydroxide	Dioctyldiphenylamine	Aluminum hydroxide Sodium hydroxide	1962 - 1986 (2)
Phenolic and Urea Formaldehyde Resins	Phenol Urea Formaldehyde	Solid and liquid resins	Phenol Formaldehyde	1961 - 1967
Phthalate Plasticizers (Dioctyl phthalate, dibutyl phthalate)	Phthalic anhydride 2-ethylhexanol Butyl alcohol	Liquid plasticizers	None	1955 - 1961
Witrol N (N-Nitrosodiphenylamine)	Diphenylamine Sodium nitrite Sulphuric acid	N-Nitrosodiphenylamine (solid)	Sodium nitrite Sodium sulphate	1965 - 1967

TABLE 2.1

PRODUCTS/RAW MATERIALS/WASTE PRODUCTION PERIODS (1)
WILMINGTON FACILITY

Process	*Raw Materials*	*Product*	*Waste By-Products*	*Process Operation Period*
Coatings	Bentone Santocel Ufamite MM 67 Toluene Butylacetate Acrylic Resins Maleic Anhydride Glycerine Fatty Amines Silicone Monoethanolamine		Compounded on a batch basis with no waste	Various Times

Notes:

(1) Table 2.1 was compiled from documents provided by Stepan in the sale of the Facility to Olin Corporation and an August 21, 1969 Badger Company Report, Pollution Control Study for National Polychemicals Inc. at Wilmington, MA.
(2) Process operations ending in 1986 were assumed to be in operation until this time based on a 1982 Olin Corporation specialty polymer additives brochure.
(3) Up to 1967, sodium dichromate was used in the process instead of sodium chlorate. The by-product waste contained chrome sulphate instead of sodium chloride and sodium sulphate.
(4) This process was shut down in the fall of 1970 with hydrazine then purchased from Olin Corporation.
(5) Limited quantities, 24,000 lb/yr.

TABLE 2.2

IDENTIFIED SOLID WASTE MANAGEMENT UNITS (SWMUs)
WILMINGTON FACILITY

Item	*Description of Identified SWMU*
1.	Plant D Drum Storage Unit
2.	Plant B Drum Storage Unit
3.	By-Product HCl Tank
4.	By-Product Ammonium Hydroxide Tank
5.	By-Product Ammonium Hydroxide Tank
6.	By-Product Ammonium Hydroxide Tank (Removed)
7.	By-Product Ammonium Hydroxide Tank
8.	Wastewater Treatment Plant
9.	Lagoon I
10.	Lagoon II
11.	Plant B pit
12.	Calcium Sulphate Landfill
13.	Interceptor Well System
14.	Lake Poly
15.	Acid Pits
16.	Trench in the vicinity of the East and West Warehouses
17.	Opex Vicinity of Lagoon I
18.	Opex Drums West of West Warehouse
19.	Drums North of Lagoon II
20.	Septic Tank, Active
21.	Tile Field, Inactive
22.	PCB Capacitor
23.	Plant B Production Area and Tank Farm
24.	Spills from Wytox Loading Area (surface soil removed, material in water table)
25.	Fuel Oil Spills near Firewater Tank
26.	Black Area East of Plant D (surface soil removed)
27.	Black Area Near West Ditch
28.	West Ditch Oily Material Under Sediment.
29.	South Ditch White Sediment and Oily Material
30.	Black Oily Material on Bank of South Ditch
31.	Wastewater Treatment Sump
32.	Oil Water Separator (NPDES Discharge Point)
33.	Area Near GW-55 Well Nest
34.	Removed Fuel Tank Area

TABLE 3.1

SUMMARY OF WILMINGTON TOWN WELLS WEST OF FACILITY
WILMINGTON FACILITY

Well Location	*Maximum Design Yeild* MGD	*Maximum Design Yeild* GPM	*Average Pumping Rate* MGD	*Average Pumping Rate* GPM	*Screened Interval ft bgs*
Chestnut Street	1.4	950	0.5	350	45-55
Town Park	0.5	350	0.2	180	29-39
Butters Row #1	1.3	900	0.7	450	39-51.5
Butters Row #2	1.4	950	0.9	650	36-46
Total	4.6	3,150	2.3	1,630	

Notes:

ft bgs feet below ground surface
MGD million gallons per day
GPM gallons per minute
(1) Source : Aquifer Protection Study, Town of Wilmington, June 1990, IEP, INC.

TABLE 3.2

PRIVATE WELL SUMMARY IN VICINITY OF FACILITY
WILMINGTON FACILITY

Plot #	*Parcel #*	*Location*	*Water Source*	*Unit*	*Approximate Date Well Connected to Town Water*
24	54	Cooke Ave.	Well	Bedrock	NA
24	64	Cooke Ave.	Well	Bedrock	NA
24	65	Cooke Ave.	Well	Bedrock	NA
24	66	Cooke Ave.	Well	Bedrock	NA
24	72A	Cooke Ave.	Well	Bedrock	NA
24	94	Cooke Ave.	Well	Bedrock	NA
24	87A	Border Ave.	Well	Bedrock	NA
24	116	Border Ave.	Well	Bedrock	NA
24	117	Border Ave.	Well	Bedrock	NA
25	3	Main St.	Well (1)	Shallow Sand & Gravel	NA
25	4	Main St.	Well (1)	Shallow Sand & Gravel	NA
25	6	Main St.	Well (1)	Shallow Sand & Gravel	NA
25	7	Main St.	Well (1)	Shallow Sand & Gravel	NA
25	8	Main St.	Well (1)	Shallow Sand & Gravel	NA
25	9	Main St.	Town	--	1983
25	10	Main St.	Town	--	1984
25	11	Main St.	Town	--	1959
25	12	Main St.	Town	--	~1959
25	13	Main St.	Town	--	~1959
26	2	Main St.	Town	--	1957
26	3	Main St.	Town	--	1970-73
26	4	Main St.	Town	--	1957-59
26	5	Main St.	Town	--	1959
26	6	Main St.	Town	--	1957
26	7a	Main St.	Town	--	1973
26	7b	Main St.	Town	--	1970-73
26	7c	Main St.	Town	--	1970-73
26	7d	Main St.	Town	--	1973
26	8	Main St.	Town	--	1957

Notes:

(1) According to information provided by Olin, residents use bottled water or pretreat water for drinking.

NA Not applicable.

TABLE 4.1

CSA FIELD ACTIVITIES SUMMARY
WILMINGTON FACILITY

Activity	*Dates*
Residential Well Sampling	Oct. 90, Sept. 91.
Aerial Photo/Topographic Surveys	Dec. 90, Dec. 91.
Magnetometer Surveys	Dec. 90, Jan. 91.
Monitoring Well Installations	June 91, July 91, Dec. 91, Jan. 92, Feb. 92, April 92, May 92, July 92, Aug. 92, Nov. 92, Dec. 92, Jan. 93, Mar. 93, April 93, May 93.
Investigative Soil Borings	June 91, Feb. 92.
Slug Testing/Pump Testing	July 91, Feb. 92, Jan. 93.
Surface Soil Sampling	July 91, May 93.
Groundwater Sampling	Aug. 91, Dec. 91, Feb. 92, May 92, Aug. 92, Nov. 92, Dec. 92, Jan. 93, April 93, May 93.
Water Level Monitoring	Sept. 91, Feb. 92, July 92, Aug. 92, Sept. 92, Jan. 93, April 93.
Surface Water/Sediment Sampling	Oct. 91, Dec. 91, Aug. 92, Sept. 92, Nov. 92, Dec. 92, Jan. 93, Mar. 93, April 93.
Seismic Refraction Surveys	Oct. 91, Feb. 92.
Test Pit Excavations	Oct. 91, July 92.
Soil Gas Survey	Feb. 92.
Field Reconnaissance/Geologic Mapping	Feb. 92.
Piezometer/Staff Gauge Installations	July 92, Oct. 92.
EM/Temperature Logging	Aug. 92, Dec. 92, Jan. 93.
Town Well Sampling	Sept. 92.

TABLE 4.2

TEST PIT EXCAVATION SAMPLE SUMMARY
WILMINGTON, FACILITY

Date Sampled (mm/dd/yy)	*Sample ID*	*Test Pit Location*	*Matrix*	*Sample Description*
10/02/91	S-01-TP-1	TP-1	Soil	Black, sandy silt, slight odor
10/02/91	DS-02-TP-6	TP-6	Drum	Dark gray greasy compound
10/03/91	DS-03-TP-8	TP-8	Drum	Milky white viscous compound
10/03/91	DS-04-TP-8	TP-8	Drum	Green-Blue granular compound with strong OVA reading (>200 ppm)
10/03/91	DS-04-TP-8	TP-8	Drum	Duplicate of DS-04-TP-8
10/07/91	S-06-TP-19	TP-19	Soil	Black, silty sand with strong OVA reading (270 ppm)
10/08/91	DS-07-TP-21	TP-21	Drum	Brittle black resin with strong OVA reading (>520 ppm)
10/08/91	S-08-TP-21	TP-21	Soil	Milky white and blue gray compounds mixed with sandy soil, moderate OVA reading (82 ppm)

TABLE 4.3

SUMMARY OF HNU SCREENING
WAREHOUSE TEST PITS
WILMINGTON, FACILITY

Test Pit Location	*Sample Depth ((ft bgs)*	*Date Sampled (mm/dd/yy)*	*HNU Reading (ppm)*	*Sample Description*
Eastern Warehouse				
WHTP-1	12.0	07/29/92	0.0	Sand and Gravel
WHTP-2	12.0	07/28/92	0.0	Sand and Gravel
WHTP-3	11.0	07/28/92	0.0	Sand and Gravel
WHTP-4	10.5	07/28/92	0.0	Sand and Gravel
WHTP-5	10.0	07/28/92	0.0	Sand and Gravel
Between Warehouses				
WHTP-6	9.0	07/29/92	0.0	Gravel
WHTP-7	9.0	07/29/92	0.0	Gravel
Western Warehouse				
WHTP-8	10.0	07/30/92	0.0	Sand and Gravel
WHTP-9	1.0	07/30/92	0.0	Sand and Gravel

Notes:

ft bgs - feet below ground surface
ppm - parts per million

TABLE 4.4

MONITORING WELL COMPLETION DETAILS SUMMARY
WILMINGTON FACILITY

Monitoring Well I.D.	Date Completed (mm/dd/yy)	Ground Elevation (ft. AMSL)	Top of Casing Elevation (ft AMSL)	Monitored (Screened) Interval		Sand Pack Interval		Well Materials	Top of Bedrock	
				Elevation (ft AMSL)	Depth (ft bgs)	Elevation (ft AMSL)	Depth (ft bgs)		Depth (ft bgs)	Elev (ft AMSL)
GW Monitoring Wells										
GW-1	10/26/77	87.8	88.89	73.3-68.3	14.5-19.5	87.8-67.8	0-20.0	1.5"Ø PVC casing/screen	NA	NA
GW-2*	11/01/77	87.6	88.10	78.1-73.1	9.5-14.5	87.6-72.6	0-15.0	1.5"Ø PVC casing/screen	NA	NA
GW-3S	11/01/77	85.4	86.69	75.4-70.4	10.0-15.0	85.4-70.4	0-15.0	1.5"Ø PVC casing/screen	NA	NA
GW-3D	06/25/86	84.1	85.23	71.2-61.2	12.9-22.9	?-61.2	?-22.9	1.5"Ø PVC casing/screen	22.9	61.2
GW-4	10/31/77	79.8	82.12	71.8-66.8	8.0-13.0	79.8-66.8	0-13.0	1.5"Ø PVC casing/screen	NA	NA
GW-4D	06/21/91	77.5	79.23	68.5-58.5	9.0-19.0	70.5-56.5	2.0-21.0	2" Ø PVC casing/screen	14.2	63.3
GW-5	10/28/77	76.3	79.46	71.3-66.3	5.0-10.0	76.3-66.3	0-10.0	1.5"Ø PVC casing/screen	NA	NA
GW-6S	10/28/77	87.2	88.72	79.0-74.0	8.2-13.2	87.2-72.2	0-15.0	1.5"Ø PVC casing/screen	NA	NA
GW-6D	06/17/86	87.9	89.43	70.5-60.5	17.4-27.4	?-60.5	?-27.4	1.5"Ø PVC casing/screen	27.4	60.5
GW-7	10/27/77	82.7	84.81	74.2-69.2	8.5-13.5	82.7-68.7	0-14.0	1.5"Ø PVC casing/screen	NA	NA
GW-8	10/28/77	77.8	83.19	74.6-69.6	3.2-8.2	77.8-67.8	0-10.0	1.5"Ø PVC casing/screen	NA	NA
GW-10S	11/02/77	87.1	89.61	82.3-77.3	4.8-9.8	87.1-77.1	0-10.0	1.5"Ø PVC casing/screen	NA	NA
GW-10D	07/11/86	83.5	84.19	66.3-56.3	17.2-27.2	?-56.3	?-27.2	1.5"Ø PVC casing/screen	27.2	56.3
GW-11	10/31/77	85.6	87.22	76.6-71.6	9.0-14.0	85.6-70.6	0-15.0	1.5"Ø PVC casing/screen	NA	NA
GW-12	11/02/77	82.0	84.62	77.2-72.2	4.8-9.8	82.0-72.0	0-10.0	1.5"Ø PVC casing/screen	NA	NA
GW-13	12/03/80	89.0	90.62	75.5-70.5	13.5-18.5	76.5-70.5	12.5-18.5	3"ØPVC casing/screen	NA	NA
GW-14	12/04/80	87.4	88.70	79.9-74.9	7.5-12.5	80.9-74.9	6.5-12.5	4"ØPVC casing/screen	NA	NA
GW-15	12/07/80	88.7	90.07	74.2-69.2	14.5-19.5	75.2-69.2	13.5-19.5	3"ØPVC casing/screen	NA	NA
GW-16	12/04/80	90.1	91.18	80.1-75.1	10.0-15.0	81.1-75.1	9.0-15.0	3"ØPVC casing/screen	NA	NA
GW-17S	03/04/81	79.7	82.10	76.7-71.7	3.0-8.0	77.7-71.7	2.0-8.0	2"ØPVC casing/screen	NA	NA
GW-17D	03/03/81	79.6	81.46	72.6-67.6	7.0-12.0	72.6-67.6	7.0-12.0	2"ØPVC casing/screen	13.0	66.6
GW-18S	02/25/81	86.7	89.64	86.7-76.7	5.0-10.0	83.7-76.7	3.0-10.0	2"ØPVC casing/screen	NA	NA
GW18D	02/24/81	86.7	88.96	72.2-67.2	14.5-19.5	76.7-66.7	10.0-20.0	2"ØPVC casing/screen	19.9	66.8
GW-19S	02/12/81	88.2	89.88	83.2-78.2	5.0-10.0	84.7-78.2	3.5-10.0	2"ØPVC casing/screen	NA	NA
GW-19D	02/09/81	87.8	89.78	73.1-68.1	14.7-19.7	77.8-67.8	10.0-20.0	2"ØPVC casing/screen	20.0	67.8
GW-20	02/26/81	83.4	85.60	73.7-68.7	9.7-14.7	75.4-68.4	8.0-15.0	2"ØPVC casing/screen	15.0	68.4
GW-21S	06/25/86	89.6	90.90	80.2-70.2	9.4-19.4	?-70.2	? - 19.4	1.5"ØPVC casing/screen	NA	NA
GW-21D	03/05/81	84.1	86.08	74.6-69.6	9.5-14.5	80.1-69.1	4.0-15.0	2"ØPVC casing/screen	15.0	69.1
GW-22S	03/05/81	85.6	87.32	75.6-70.6	10.0-15.0	77.6-70.6	8.0-15.0	2"ØPVC casing/screen	NA	NA
GW-22D	03/04/81	85.6	87.06	55.6-50.6	30.0-35.0	70.6-49.6	15.0-36.0	2"ØPVC casing/screen	36.0	49.6
GW-23		88.5	90.93						15.0	73.5
GW-24			83.57	S	S	S	S		NA	NA
GW-25			85.99	S	S	S	S		NA	NA
GW-26			84.96	S	S	S	S		NA	NA
GW-27S	06/19/86	88.1	89.40	78.1-68.1	10.0-20.0	?-68.1	?-20.0	1.5"Ø PVC casing/screen	NA	NA
GW-27D	06/20/86	88.4	89.40	67.5-57.5	20.9-30.9	?-57.5	?-30.9	1.5"Ø PVC casing/screen	NA	NA
GW-28S	06/27/86	83.6	85.57	81.6-71.6	2.0-12.0	?-71.6	?-12.0	1.5"Ø PVC casing/screen	NA	NA
GW-28D	06/27/86	83.5	84.81	79.2-69.2	4.3-14.3	?-69.2	?14.3	1.5"Ø PVC casing/screen	NA	NA
GW-29S	07/03/86	83.9	84.27	79.9-69.9	4.0-14.0	?-69.9	?-14.0	1.5"Ø PVC casing/screen	14.3	69.2
GW-29D	07/10/86	83.8	84.58	64.8-54.8	19.0-29.0	?-54.8	?-29.0	1.5"Ø PVC casing/screen	NA	NA
GW-30S*	07/02/86	90.9	91.0	81.9-71.9	9.0-19.0	?-71.9	?-19.0	1.5"Ø PVC casing/screen	NA	NA
GW-30DR	11/18/87	87.7	89.32	56.2-46.2	31.5-41.5	?-46.2	?-41.5	2" ØPVC casing/screen	39.5	48.2
GW-30D*	06/30/86	90.7	85.57	58.0-48.0	32.7-42.7	?-48.0	?-42.7	1.5"Ø PVC casing/screen	42.7	48.0

TABLE 4.4

MONITORING WELL COMPLETION DETAILS SUMMARY
WILMINGTON FACILITY

Monitoring Well I.D.	Date Completed (mm/dd/yy)	Ground Elevation (ft. AMSL)	Top of Casing Elevation (ft AMSL)	Monitored (Screened) Interval Elevation (ft AMSL)	Monitored (Screened) Interval Depth (ft bgs)	Sand Pack Interval Elevation (ft AMSL)	Sand Pack Interval Depth (ft bgs)	Well Materials	Top of Bedrock Depth (ft bgs)	Top of Bedrock Elev (ft AMSL)
GW-31S	04/12/88		91.41		6.0-16.0		?-16.0	2"Ø SS casing/screen	NA	NA
GW-31D	04/12/88	67.2	91.68	55.2 - 45.2	12.0-22.0	? - 45.2	?-22.0	2"Ø SS casing/screen	22.0	67.2
GW-32S	04/14/88		87.74		5.0-15.0		?-15.0	2"Ø SS casing/screen	NA	NA
GW-32D	04/14/88	86.7	89.20	65.7 - 55.7	21.0-31.0	? - 55.7	?-31.0	2"Ø SS casing/screen	26.0	60.7
GW-33S	11/13/89	87.4	89.88	77.4-67.4	10.0-20.00	78.4-67.4	9.0-20.0	2"ØPVC casing/screen	NA	NA
GW-33D	11/13/89	88.1	89.64	71.1-61.1	16.0-26.0	73.1-61.1	14.0-26.0	2"ØPVC casing/screen	19.4	68.7
GW-34S	11/17/89	87.7	90.21	77.7-67.7	10.0-20.0	78.7-67.7	9.0-20.0	2"ØPVC casing/screen	NA	NA
GW-34D	11/20/89	88.0	90.27	65.3-55.3	23.0-33.0	68.3-55.3	20.0-33.0	2"ØPVC casing/screen	Boulders (24.5)	Boulders (63.5)
GW-35S	11/28/89	87.1	89.57	77.1-67.1	10.0-20.0	79.1-67.1	8.0-20.0	2"ØPVC casing/screen	NA	NA
GW-35D	11/25/89	88.1	89.76	57.3-47.3	30.0-40.0	59.3-47.3	28.0-40.0	2"ØPVC casing/screen	35.0	53.1
GW-36	11/16/89	84.3	85.77	57.3-47.3	27.0-37.0	61.3-47.3	23.0-37.0	2"ØPVC casing/screen	36.5	47.8
GW-37	11/?/89	81.8	83.51	62.5-52.5	19.5-29.5	68.0-52.5	14.0-29.5	2"ØPVC casing/screen	27.0	55.0
GW-38	11/13/89	85.9	86.95	65.0-55.0	20.5-30.5	71.5-55.0	14.0-30.5	2"ØPVC casing/screen	28.0	57.5
GW-39	11/28/89	81.7	83.55	78.6-68.6	3.0-13.0	80.6-68.6	1.0-13.0	2"ØPVC casing/screen	8.0	73.6
GW-40D	07/26/91	86.4	88.00	51.4-41.4	35.0-45.0	53.4-41.4	33.0-45.0	2"ØPVC casing/screen	39.0	47.4
GW-40S	07/26/91	86.4	88.46	76.4-66.4	10.0-20.0	78.4-66.4	8.0-20.0	2"ØPVC casing/screen	NA	NA
GW-42D	07/21/91	84.4	84.41	50.4-40.4	34.0-44.0	54.4-40.4	30.0-44.0	2"ØPVC casing/screen	39.0	45.4
GW-42S	07/21/91	84.5	84.52	76.0-66.0	8.5-18.5	78.5-66.0	6.0-18.5	2"ØPVC casing/screen	NA	NA
GW-43D	07/18/91	85.6	87.97	60.6-50.6	25.0-35.0	65.6-50.6	20.0-35.0	2"ØPVC casing/screen	29.0	56.5
GW-43S	07/18/91	85.6	87.36	77.6-67.6	8.0-18.0	79.6-67.6	6.0-18.0	2"ØPVC casing/screen	NA	NA
GW-44S	04/24/92	84.0	85.70	74.0-64.0	10.0-20.0	76.0-64.0	8.0-20.0	2"ØPVC casing/screen	NA	NA
GW-44D	04/24/92	83.5	93.97	28.5-18.5	55.0-65.0	30.5-16.5	53.0-67.0	2"ØPVC casing/screen	61.0	22.5
GW-45S	12/11/92	89.9	89.43	77.9-67.9	12.0-22.0	81.9-67.9	8.0-22.0	2"ØPVC casing/screen	NA	NA
GW-45D	12/11/92	89.8	89.36	37.3-27.3	52.5-62.5	41.8-25.3	48.0-64.5	2"ØPVC casing/screen	60.0	29.8
GW-46D	01/31/92	84.2	85.90	76.2-66.2	8.0-18.0	78.2-66.2	6.0-18.0	2"ØPVC casing/screen	14.0	70.2
GW-47	08/02/91	91.6	93.18	87.6-77.6	4.0-14.0	88.6-77.6	3.0-14.0	2"ØPVC casing/screen	3.0	88.6
GW-48D	07/16/91	89.0	90.86	48.0-38.0	41.0-51.0	60.0-48.0	29.0-41.0	2"ØPVC casing/screen	36.0	53.0
GW-48S	07/16/91	88.9	91.14	76.9-66.9	12.0-22.0	78.9-66.9	10.0-22.0	2"ØPVC casing/screen	NA	NA
GW-49D	12/14/92	79.2	81.37	71.2-61.2	8.0-18.0	73.2-61.2	6.0-18.0	2"ØPVC casing/screen	NA	NA
GW-50D	06/27/91	77.4	80.11	47.4-37.4	30.0-40.0	49.4-37.4	28.0-40.0	2"ØPVC casing/screen	35.0	42.4
GW-50S	06/27/91	77.0	79.71	72.0-62.0	5.0-15.0	73.0-62.0	4.0-15.0	2"ØPVC casing/screen	NA	NA
GW-51D	06/19/91	82.8	84.52	71.8-61.8	11.0-21.0	75.0-63.8	7.8-19.0	2"ØPVC casing/screen	14.0	68.8
GW-51S	06/19/91	82.9	84.59	79.9-74.9	3.0-8.0	80.4-74.9	2.5-8.0	2"ØPVC casing/screen	NA	NA
GW-52D	06/18/91	85.8	88.00	73.8-63.8	12.0-22.0	76.8-63.8	9.0-22.0	2"ØPVC casing/screen	15.0	70.8
GW-52S	06/13/91	85.8	87.99	80.6-75.6	5.0-10.0	82.6-75.1	3.0-10.5	2"ØPVC casing/screen	NA	NA
GW-53D	06/17/91	89.3	91.88	77.8-67.8	11.5-21.5	79.8-67.3	9.5-22.0	2"ØPVC casing/screen	15.0	74.3
GW-53S	06/13/91	89.0	90.69	83.5-78.5	5.5-10.5	86.0-78.5	3.0-10.5	2"ØPVC casing/screen	NA	NA
GW-54D	06/14/91	86.6	89.15	76.1-66.1	10.5-20.5	77.6-66.1	9.0-20.5	2"ØPVC casing/screen	15.3	71.3
GW-54S	06/13/91	86.4	88.69	81.4-76.4	5.0-10.0	82.4-76.2	4.0-10.2	2"ØPVC casing/screen	NA	NA
GW-55D	07/02/91	79.7	81.73	69.7-59.7	10.0-20.0	69.7-59.7	10.0-20.0	2"ØPVC casing/screen	14.0	65.7
GW-55S	07/02/91	79.8	81.44	74.8-69.8	5.0-10.0	75.8-69.8	4.0-10.0	2"ØPVC casing/screen	NA	NA
GW-56D	07/09/91	80.5	82.76	65.5-55.5	15.0-25.0	67.5-55.5	13.0-25.0	2"ØPVC casing/screen	19.5	61
GW-56S	07/09/91	80.6	83.01	75.6-65.6	5.0-15.0	77.6-65.6	3.0-15.0	2"ØPVC casing/screen	NA	NA
GW-57D	01/29/91	95.3	94.99	74.3-64.3	21.0-31.0	77.3-64.3	18.0-31.0	2"ØPVC casing/screen	26.0	69.3
GW-58D	08/03/92	96.1	98.19	26.1-16.1	70.0-80.0	29.1-16.1	67.0-80.0	2"ØPVC casing/screen	74.0	22.1
GW-58S	08/03/92	96.0	98.21	78.0-68.0	18.0-28.0	80.0-68.0	16.0-28.0	2"ØPVC casing/screen	NA	NA

TABLE 4.4

MONITORING WELL COMPLETION DETAILS SUMMARY
WILMINGTON FACILITY

Monitoring Well I.D.	Date Completed (mm/dd/yy)	Ground Elevation (ft. AMSL)	Top of Casing Elevation (ft AMSL)	Monitored (Screened) Interval		Sand Pack Interval		Well Materials	Top of Bedrock	
				Elevation (ft AMSL)	Depth (ft bgs)	Elevation (ft AMSL)	Depth (ft bgs)		Depth (ft bgs)	Elev (ft AMSL)
GW-59S	02/07/92	85.3	85.08	75.3-65.3	10.0-20.0	77.3-65.3	8.0-20.0	2"ØPVC casing/screen	NA	NA
GW-59D	02/07/92	85.2	85.06	36.2-21.2	49.0-64.0	38.2-20.2	47.0-65.0	2"ØPVC casing/screen	60.0	25.2
GW-60S	04/29/92	88.9	90.48	81.9-71.9	7.0-17.0	83.9-70.9	5.0-18.0	2"ØPVC casing/screen	NA	NA
GW-60D	04/29/92	88.6	90.73	67.6-57.6	21.0-31.0	70.6-57.6	18.0-31.0	2"ØPVC casing/screen	26.0	62.6
GW-61BR	12/17/92	81.6	83.67	9.6- -10.4	72.0-92.0	NA	NA	4"ØPVC casing	72.0	9.6
GW-61S	04/30/92	81.7	83.51	71.7-61.7	10.0-20.0	73.7-61.7	8.0-20.0	2"ØPVC casing/screen	NA	NA
GW-61D	04/30/92	81.5	83.66	40.5-30.5	41.0-51.0	43.5-29.5	38.0-52.0	2"ØPVC casing/screen	48.0	33.5
GW-62BRD	01/06/93	82.0	83.66	-23.0- -63.0	105.0-145.0	NA	NA	4"ØPVC casing	80.0	2.0
GW-62BR	07/22/92	81.6	83.67	-1.6- -23.4	80.0-105.0	NA	NA	4"ØPVC casing	80.0	1.6
GW-62S	05/05/92	82.3	84.61	77.3-67.3	5.0-15.0	79.3-67.3	3.0-15.0	2"ØPVC casing/screen	NA	NA
GW-62D	05/04/92	82.4	83.84	21.4-11.4	61.0-71.0	24.4-7.4	58.0-75.0	2"ØPVC casing/screen	70.0	12.4
GW-62M	05/05/92	82.4	84.38	52.4-42.4	30.0-40.0	54.4-42.4	28.0-40.0	2"ØPVC casing/screen	NA	NA
GW-63S	08/05/92	81.1	82.82	73.1-63.1	8.0-18.0	75.1-63.1	6.0-18.0	2"ØPVC casing/screen	NA	NA
GW-63D	08/05/92	81.1	83.32	57.1-47.1	24.0-34.0	62.1-47.1	19.0-34.0	2"ØPVC casing/screen	29.0	52.1
GW-64S	07/31/92	84.6	86.70	74.1-64.1	10.5-20.5	76.1-64.1	8.5-20.5	2"ØPVC casing/screen	NA	NA
GW-64D	07/31/92	84.1	85.96	28.1-18.1	56.0-66.0	37.1-16.1	47.0-68.0	2"ØPVC casing/screen	63.5	20.6
GW-65S	08/07/92	82.4	84.14	74.4-64.4	8.0-18.0	76.4-64.4	6.0-18.0	2"ØPVC casing/screen	NA	NA
GW-65D	08/05/92	82.4	84.19	-3.1- -18.1	85.5-100.5	-1.1- -21.1	83.5-100.5	2"ØPVC casing/screen	93.3	-10.9
GW-66S	08/03/92	88.4	90.15	79.4-69.4	9.0-19.0	81.4-69.4	7.0-19.0	2"ØPVC casing/screen	NA	NA
GW-66D	07/22/92	88.3	90.37	55.3-44.3	33.0-43.0	57.3-40.8	31.0-47.5	2"ØPVC casing/screen	40.0	48.3
GW-67S	11/02/92	98.4	100.61	80.9-70.9	17.5-27.5	83.4-70.4	15.0-28.0	2"ØPVC casing/screen	NA	NA
GW-67D	11/02/92	98.2	100.39	25.7-10.7	72.5-87.5	30.2-10.2	68.0-88.0	2"ØPVC casing/screen	81.0	17.2
GW-68BR	12/10/92	90.2	89.83	59.2-14.2	31.0-76.0	NA	NA	4"ØPVC casing	31.0	59.2
GW-68D	07/23/92	90.3	90.16	83.3-73.3	7.0-17.0	85.3-72.3	5.0-18.0	2"ØPVC casing/screen	14.0	76.3
GW-69S	07/27/92	90.9	92.28	77.9-67.9	13.0-23.0	82.4-67.9	8.5-23.0	2"ØPVC casing/screen	NA	NA
GW-69D	07/27/92	91.1	93.05	55.1-45.1	36.0-46.0	57.1-45.1	34.0-46.0	2"ØPVC casing/screen	45.0	46.1
GW-70S	07/26/92	92.2	91.99	78.2-68.2	14.0-24.0	80.2-68.2	12.0-24.0	2"ØPVC casing/screen	NA	NA
GW-70D	07/28/92	92.3	92.10	40.3-30.3	52.0-62.0	42.3-30.3	50.0-62.0	2"ØPVC casing/screen	57.0	35.3
GW-71D	11/19/92	94.4	96.65	54.4-44.4	40.0-50.0	57.4-44.1	37.0-50.3	2"ØPVC casing/screen	45.0	49.4
GW-71S	11/17/92	93.9	95.60	80.9-70.9	13.0-23.0	87.9-70.9	6.0-23.0	2"ØPVC casing/screen	NA	NA
GW-72D	11/17/92	86.0	88.19	74.0-64.0	12.0-22.0	76.0-61.0	10.0-25.0	2"ØPVC casing/screen	17.0	69
GW-73D	04/19/93	83.8	83.49	29.3-19.3	54.5-64.5	31.3-19.3	52.5-64.5	2"ØPVC casing/screen	58.0	25.8
GW-73S	04/19/93	83.4	83.39	68.4-58.4	15.0-25.0	70.4-58.4	13.0-25.0	2"ØPVC casing/screen	NA	NA
GW-74D	03/31/93	77.7	77.22	57.2-47.2	20.5-30.5	59.7-47.2	18.0-30.5	2"ØPVC casing/screen	25.0	52.7
GW-74S	03/31/93	77.7	77.43	67.7-57.7	10.0-20.0	69.7-57.7	8.0-20.0	2"ØPVC casing/screen	NA	NA
GW-75D	05/06/93	81.4	83.49	45.4-35.4	36.0-46.0	47.4-35.4	34.0-46.0	2"ØPVC casing/screen	41.0	40.4
GW-75S	05/06/93	81.1	83.28	71.1-61.1	10.0-20.0	73.1-61.1	8.0-20.0	2"ØPVC casing/screen	NA	NA
Sulfate Landfill Monitoring Wells										
SL1S	11/11/87		86.47		5.0-15.0		?-15.0	2"Ø PVC casing/screen	NA	NA
SL1D	11/12/87		86.44		4.5-14.5		?-14.5	2"Ø PVC casing/screen	12.5	71.6
SL2	11/13/87		85.80		5.0-15.0		?-15.0	2"Ø PVC casing/screen	13.0	70.5
SL3	11/20/87		92.64		11.0-21.0		?-21.0	2"Ø PVC casing/screen	19.0	71.2
SL4	11/16/87		103.19		5.7-10.7		?-10.7	2"Ø PVC casing/screen	8.0	92.7
SL5	11/17/87		94.41		5.0-15.0		?-15.0	2"Ø PVC casing/screen	13.0	79.8
SL6	11/18/87		92.71		11.0-21.0		?-21.0	2"Ø PVC casing/screen	19.0	71.1
SL7	11/19/87		95.25		5.0-10.0		?-10.0	2"Ø PVC casing/screen	7.0	86.3
SL8	11/19/87		92.42		1.0-6.0		?-6.0	2"Ø PVC casing/screen	3.0	87.9

TABLE 4.4

MONITORING WELL COMPLETION DETAILS SUMMARY
WILMINGTON FACILITY

Monitoring Well I.D.	Date Completed (mm/dd/yy)	Ground Elevation (ft. AMSL)	Top of Casing Elevation (ft AMSL)	Monitored (Screened) Interval Elevation (ft AMSL)	Monitored (Screened) Interval Depth (ft bgs)	Sand Pack Interval Elevation (ft AMSL)	Sand Pack Interval Depth (ft bgs)	Well Materials	Top of Bedrock Depth (ft bgs)	Top of Bedrock Elev (ft AMSL)
Other Plant Wells										
OW-1	02/10/82				5.0-15.0			4"PVC Casing/Screen	15.0	
OW-2	02/10/82				5.0-15.0			4"PVC Casing/Screen	13.0	
OW-3	02/11/82				5.0-15.0			4"PVC Casing/Screen	-	
OW-4	02/11/82				7.0-17.0			4"PVC Casing/Screen	15.0	
OB-1			85.92		4.0-19.0				19.0	
OB-2			88.00		7.5-27.5				27.5	
OB-3			88.16		3.0-28.0				28.0	
OB-4			89.41		6.0-21.0				21.0	
PW-1		86.8	87.45	78.8-28.8	8.0-28.0				27.0	59.8
PW-2	11/30/87	87.5	89.14	79.5-49.5	8.0-38.0	82.5-49.5	5.0-38.0	6" Ø PVC Casing/Screen	38.0	49.5
GT4S			86.39		4.0-9.0					
GT4D		86.3	88.51	77.3-62.3	9.0-24.0				28 0	58.3
GT5		84.1	88.03	67.6-52.6	16.5-31.5				34.0	50.1
GT6S			87.40		3.5-8.5					
GT6D		86.5	87.25	68.5-53.5	18.0-33.0				36.5	50.0
GT7			90.51		0.3-25.3					
GT8		91.6							31.0	60 6
GT9S			86.97		4.0-9.0					
GT9D			87.62		18.0-33.0					
P1D			89.77	?-71.2						
P3			88.94	?-81.3						
P4			88.73	?-76.1						
P5			88.03	?-73.9						
IW1			89.32							
IW2			89.60							
IW3			89.35							
IW4			89.66							
IW6			89.15							
IW7			90.09							
IW8			89.89							
IW9			89.74							
IW10			90.34							
IW11			89.92							
IW12			90.31							
IW13			89.90							
JOB			88.20							
JOD		87.0	89.99							

TABLE 4.4

MONITORING WELL COMPLETION DETAILS SUMMARY
WILMINGTON FACILITY

Monitoring Well I.D.	Date Completed (mm/dd/yy)	Ground Elevation (ft. AMSL)	Top of Casing Elevation (ft AMSL)	Monitored (Screened) Interval Elevation (ft AMSL)	Monitored (Screened) Interval Depth (ft bgs)	Sand Pack Interval Elevation (ft AMSL)	Sand Pack Interval Depth (ft bgs)	Well Materials	Top of Bedrock Depth (ft bgs)	Top of Bedrock Elev (ft AMSL)
JOE		87.5	89.78							
JOF		87.0	89.93							
JOG			90.10							
JOH			90.51							
JOI			91.73							
B2	10/16/87		88.44	?-74.4					23.0	
B3	10/18/87		88.91	?-74.6					24.0	
B5	10/19/87		90.39	?-78.4					24.0	
B7A	10/21/87		89.03	?-78.5					23.0	
B15*			90.07							
B17			90.67	?-77.5						
12-IN			89.78							

Notes:

* - destroyed
NA - Not applicable/not determined
S - Shallow well, depth and screen not recorded
ft AMSL - feet above Mean Sea Level
ft bgs - feet below ground surface

TABLE 4.5

HYDRAULIC CONDUCTIVITY DATA RESULTS
WILMINGTON FACILITY

Well No.	*Hydraulic Conductivity (cm/sec)(1)*		
Slug Test Results			
	Falling Head Test	*Rising Head Test*	*Average*
40D	$>1 \times 10^{-2}$	--	$>1 \times 10^{-2}$ (2)
42D	$>1 \times 10^{-2}$	--	$>1 \times 10^{-2}$ (2)
43D	1×10^{-2}	9.0×10^{-3}	9.5×10^{-3}
50D	$>1 \times 10^{-2}$	--	$>1 \times 10^{-2}$ (2)
51D	--	9.7×10^{-4}	9.7×10^{-4}
54D	5.3×10^{-3}	3.4×10^{-3}	4.4×10^{-3}
55D	4.3×10^{-3}	1.1×10^{-2}	7.7×10^{-3}
56D	7.7×10^{-2}	2.1×10^{-2}	4.9×10^{-2}
		Geometric Mean	7.9×10^{-3}

Pumping Test Results	*Drawdown Test*		*Recovery Test*
	Theis Solution	*Cooper-Jacob Solution*	*Cooper-Jacob Solution*
GW-62BR	1.20×10^{-5}	2.26×10^{-5}	2.13×10^{-5}
GW-62BRD	--	--	1.27×10^{-5}

Notes:

(1) See Appendix F for Hydraulic Conductivity Test Results/Calculations.
(2) Hydraulic conductivities assumed equal to 1×10^{-2} cm/sec for calculating geometric mean.

TABLE 4.6

SUMMARY OF GROUNDWATER ELEVATIONS
WILMINGTON FACILITY

Monitoring Well I.D.	Top of Casing Elevation (ft AMSL)	Water Level (ft AMSL) 09/30/91	02/11/92	07/22/92	08/14/92	09/03/92	01/07/93	04/21/93
GW Monitoring Wells								
GW-1	88.89	--	79.99	--	79.94	79.90	80.61	80.71
GW-3S	86.69	79.74	79.79	78.14	78.23	78.19	81.06	81.13
GW-3D	85.23	79.93	79.33	78.08	78.41	78.37	80.82	80.81
GW-4	82.12	76.31	76.42	75.52	78.78	75.66	76.76	76.84
GW-4D	79.23	76.66	76.13	75.41	--	75.62	77.07	77.07
GW-5	79.46	--	76.61	75.26	--	75.49	76.89	76.84
GW-6S	88.72	82.22	81.32	80.77	79.87	80.98	82.77	83.17
GW-6D	89.43	81.66	80.83	80.18	80.27	80.47	82.11	82.32
GW-8	83.19	78.67	--	76.76	77.95	76.86	79.10	79.03
GW-10S	89.61	80.96	81.11	80.16	80.32	81.74	81.81	81.39
GW-10D	84.19	81.06	80.79	80.29	80.32	80.35	81.32	81.47
GW-11	87.22	80.71	80.22	79.67	80.03	80.00	80.99	81.05
GW-12	84.62	81.02	81.02	79.80	80.27	79.80	81.65	81.61
GW-13	90.62	78.92	--	--	--	DRY	DRY	79.10
GW-15	90.07	--	79.97	79.67	79.83	79.90	81.35	81.96
GW-17S	82.10	78.81	78.30	76.75	DRY	77.05	79.24	79.14
GW-17D	81.46	78.75	78.26	--	77.52	77.19	79.14	79.14
GW-18S	89.64	DRY	DRY	DRY	DRY	DRY	78.94	79.27
GW18D	88.96	76.21	75.21	75.21	75.14	75.02	78.11	79.02
GW-19S	89.88	81.53	--	--	80.14	80.23	82.15	82.16
GW-19D	89.78	81.28	--	--	80.20	80.27	81.68	81.74
GW-20	85.60	78.00	76.79	76.79	76.25	76.35	80.21	80.26
GW-21S	90.90	83.52	82.20	82.20	--	82.47	83.80	83.85
GW-21D	86.08	83.19	81.53	81.53	82.08	81.68	83.63	83.78
GW-22S	87.32	82.90	80.92	80.92	80.92	81.22	83.05	83.10
GW-22D	87.06	80.87	79.91	79.91	--	79.78	81.16	81.50
GW-24	83.57	80.62	80.37	80.37	80.43	80.58	81.45	81.28
GW-25	85.99	80.39	79.83	79.83	81.05	80.02	80.59	80.73
GW-26	84.96	80.91	80.13	80.13	80.32	80.27	81.16	81.24
GW-27S	89.40	81.15	--	--	80.18	80.31	81.58	81.78
GW-27D	89.40	81.24	--	--	80.04	80.15	81.45	81.64
GW-28S	85.57	82.86	81.12	81.12	81.36	81.30	83.45	83.50
GW-28D	84.81	82.81	81.11	81.11	81.35	81.33	83.41	83.46
GW-29S	84.27	81.56	80.37	80.37	81.93	81.71	83.04	82.97
GW-29D	84.58	81.36	80.23	80.23	80.30	80.38	81.56	81.69
GW-30DR	89.32	80.06	79.12	79.12	--	79.28	80.35	80.65
GW-31S	91.41	81.12	80.23	80.23	80.27	80.29	81.66	82.30
GW-31D	91.68	81.23	80.63	80.26	80.34	80.36	81.63	82.09
GW-32S	87.74	80.18	79.34	78.69	78.83	78.82	80.68	81.56
GW-32D	89.20	81.16	80.60	80.25	80.27	80.28	81.58	82.05
GW-33S	89.88	81.50	80.73	80.33	80.43	80.53	81.80	82.14
GW-33D	89.64	81.54	80.79	80.39	80.45	80.55	81.80	82.14
GW-34S	90.21	81.47	80.71	80.36	80.41	80.50	81.79	82.10
GW-34D	90.27	81.32	80.72	80.22	80.34	80.46	81.63	81.90
GW-35S	89.57	81.48	80.82	80.27	80.21	80.55	81.77	82.15
GW-35D	89.76	81.41	80.81	80.31	80.46	80.64	81.72	81.95
GW-36	85.77	81.06	80.62	80.17	80.37	80.36	81.49	81.62
GW-37	83.51	81.01	80.56	80.06	80.22	80.29	81.30	81.44
GW-38	86.95	78.76	80.35	79.85	80.07	80.09	81.13	81.21
GW-39	83.55	80.66	80.40	79.40	80.13	79.68	80.95	80.88

TABLE 4.6

SUMMARY OF GROUNDWATER ELEVATIONS
WILMINGTON FACILITY

Monitoring Well I.D.	Top of Casing Elevation (ft AMSL)	Water Level (ft AMSL) 09/30/91	02/11/92	07/22/92	08/14/92	09/03/92	01/07/93	04/21/93
GW Monitoring Wells								
GW-40D	88.00	78.28	79.05	77.80	77.42	77.34	80.15	82.28
GW-40S	88.46	78.56	79.31	78.08	77.62	77.53	80.34	83.14
GW-42D	84.17	80.27	79.67	79.72	80.80	80.23	80.94	81.18
GW-42S	84.16	80.71	80.26	80.01	80.36	80.12	80.90	81.00
GW-43D	87.97	80.79	80.37	79.98	80.35	80.26	81.01	81.15
GW-43S	87.36	81.00	80.56	80.16	80.31	80.40	81.14	81.30
GW-44D	83.97	–	80.42	78.47	78.03	78.88	80.34	80.57
GW-44S	85.70	–	80.55	81.87	80.31	80.22	81.19	81.33
GW-45D	89.36	–	80.51	80.15	80.46	80.24	81.18	81.31
GW-45S	89.43	–	80.50	80.15	81.28	80.15	81.18	–
GW-46D	85.90	–	81.35	80.75	81.75	80.59	82.52	82.43
GW-47	93.18	83.26	80.53	–	78.98	79.89	84.06	84.36
GW-48D	90.86	79.71	79.31	79.21	79.40	79.21	80.21	81.42
GW-48S	91.14	79.86	79.19	79.23	79.51	79.13	80.34	81.52
GW-49D	81.37	–	–	74.82	75.35	74.78	76.30	76.25
GW-50D	80.11	76.34	75.96	75.16	75.55	75.35	76.89	76.87
GW-50S	79.71	76.41	–	75.36	75.74	75.51	76.92	76.87
GW-51D	84.52	78.07	77.72	76.77	76.96	76.91	78.66	78.75
GW-51S	84.59	78.99	78.34	77.15	77.34	77.31	79.77	79.80
GW-52D	88.00	79.40	79.00	78.35	78.38	78.55	79.78	80.30
GW-52S	87.99	80.08	78.99	78.24	78.25	78.44	80.13	80.45
GW-53D	91.88	83.74	84.38	84.08	84.48	84.60	86.43	87.07
GW-53S	90.69	83.14	81.54	81.74	82.39	81.83	83.84	84.39
GW-54D	89.15	84.21	83.15	83.05	83.57	83.21	84.83	84.96
GW-54S	88.69	84.34	83.24	83.34	84.05	83.47	85.16	84.92
GW-55D	81.73	79.85	–	78.34	79.03	78.68	80.08	80.05
GW-55S	81.44	79.95	–	78.28	78.95	78.59	79.94	79.95
GW-56D	82.76	77.42	77.16	75.71	75.81	75.67	77.97	77.95
GW-56S	83.01	77.47	77.16	75.72	75.82	75.69	77.99	77.99
GW-57D	94.99	–	80.64	80.28	80.32	80.29	81.33	81.57
GW-58D	98.19	–	–	–	80.29	80.21	81.15	81.26
GW-58S	98.21	–	–	–	80.28	80.23	81.16	81.29
GW-59D	85.06	–	80.46	80.35	80.49	80.40	81.46	81.56
GW-59S	85.08	–	80.68	80.28	80.41	80.36	81.31	81.45
GW-60D	90.73	–	–	80.31	80.44	80.36	81.38	81.49
GW-60S	90.48	–	–	80.40	80.50	80.44	81.56	81.71
GW-61D	83.66	–	–	79.83	79.99	79.85	80.71	80.80
GW-61S	83.51	–	–	79.60	79.81	79.70	80.47	80.49
GW-61BR	83.67	–	–	–	–	–	80.87	80.94
GW-62D	83.84	–	–	80.22	80.33	80.26	81.12	81.21
GW-62S	84.61	–	–	80.20	80.33	80.28	81.10	81.20
GW-62M	84.38	–	–	80.22	80.34	80.28	81.13	81.21
GW-62BR	83.70	–	–	–	79.86	80.06	80.85	80.96
GW-62BRD	83.66	–	–	–	–	–	80.97	80.84
GW-63D	83.32	–	–	–	77.62	76.17	78.82	78.69
GW-63S	82.82	–	–	–	77.64	76.19	78.75	78.64
GW-64D	85.96	–	–	–	77.08	77.17	79.51	79.49
GW-64S	86.70	–	–	–	76.70	76.79	79.45	79.43
GW-65D	84.19	–	–	–	76.83	76.55	79.39	79.31
GW-65S	84.14	–	–	–	78.30	77.81	79.56	79.52

TABLE 4.6

SUMMARY OF GROUNDWATER ELEVATIONS
WILMINGTON FACILITY

Monitoring Well I.D.	Top of Casing Elevation (ft AMSL)	Water Level (ft AMSL) 09/30/91	02/11/92	07/22/92	08/14/92	09/03/92	01/07/93	04/21/93
GW Monitoring Wells								
GW-66D	90.32	--	--	--	80.34	80.25	81.18	81.29
GW-66S	90.15	--	--	--	80.32	80.24	81.18	81.29
GW-67D	100.39	--	--	--	--	--	81.07	81.24
GW-67S	100.61	--	--	--	--	--	81.13	81.28
GW-68D	90.16	--	--	--	81.11	80.55	82.57	82.66
GW-68BR	89.93	--	--	--	--	--	83.26	83.33
GW-69D	93.05	--	--	--	80.22	80.16	81.14	81.27
GW-69S	92.28	--	--	--	80.22	80.17	81.13	81.27
GW-70D	92.10	--	--	--	80.36	80.22	81.22	81.37
GW-70S	91.99	--	--	--	80.14	80.24	81.22	81.34
GW-71D	96.65	--	--	--	--	--	81.24	81.32
GW-71S	95.60	--	--	--	--	--	81.29	81.39
GW-72D	88.19	--	--	--	--	--	--	79.96
GW-73D	83.49	--	--	--	--	--	--	79.43
GW-73S	83.39	--	--	--	--	--	--	79.51
GW-74D	77.22	--	--	--	--	--	--	73.11
GW-74S	77.43	--	--	--	--	--	--	73.12
GW-75D	83.49	--	--	--	--	--	--	--
GW-75S	83.28	--	--	--	--	--	--	--
Sulfate Landfill Monitoring Wells								
SL1S	86.47	80.65	--	79.42	79.13	79.09	82.15	83.06
SL1D	86.44	80.48	--	79.38	79.09	79.06	82.14	83.15
SL2	85.80	78.94	--	78.45	--	77.99	80.90	83.93
SL3	92.64	78.14	--	78.18	--	77.61	80.53	83.87
SL4	103.19	DRY	--	DRY	--	DRY	DRY	DRY
SL5	94.41	78.04	--	DRY	--	DRY	81.41	81.85
SL6	92.71	78.09	--	77.62	76.71	76.96	81.76	82.00
SL7	95.25	84.02	--	--	--	DRY	84.07	84.04
SL8	92.42	DRY	--	--	--	DRY	87.75	86.40
Other Plant Wells								
GT4S	86.39	81.24	80.59	--	--	80.32	81.57	81.65
GT4D	88.51	81.26	80.71	--	--	80.47	81.65	81.83
GT5	88.03	81.28	80.73	--	80.36	80.42	81.65	81.84
GT6S	87.40	81.43	80.90	--	--	80.61	81.90	82.08
GT6D	87.25	81.27	80.75	--	--	80.46	81.65	81.83
GT7	90.51	--	81.41	80.76	--	81.39	82.84	--
GT9S	86.97	81.44	80.77	80.27	80.39	80.51	81.72	81.99
GT9D	87.62	81.42	80.82	80.27	80.39	80.50	81.72	81.99
98	87.22	79.08	78.87	78.27	--	78.39	79.57	--
99	90.81	--	80.01	79.46	--	79.59	DRY	81.14
IW10	90.34	--	--	--	--	77.51	DRY	78.05

Notes:

ft AMSL - feet Above Mean Sea Level

TABLE 4.7

PIEZOMETRIC GROUNDWATER ELEVATIONS
WILMINGTON FACILITY

Location I.D.	*Top of Piezometer/ Staff Gauge Elevation (ft AMSL)*	*Surface Water Elevation (ft AMSL)*				*Groundwater Elevation (ft AMSL)*			
		07/22/92	*09/03/92*	*01/07/93*	*04/21/93*	*07/22/92*	*09/03/92*	*01/07/93*	*04/21/93*
Piezometers									
PZ-1	80.68	79.55	79.60	79.64	80.20	79.64	79.79	79.86	80.28
PZ-2	80.41	79.37	79.59	79.61	80.22	79.47	79.66	79.69	80.23
PZ-3	80.1	79.16	79.58	--	--	79.33	79.64	--	--
PZ-4	80.19	79.34	79.57	79.64	--	79.47	79.70	79.79	--
PZ-5	80.58	79.45	79.56	79.65	80.15	79.54	79.73	79.89	80.36
PZ-6	81.01	79.53	79.63	79.78	80.23	79.76	80.03	80.39	80.61
PZ-7	81.09	79.67	79.68	79.35	80.22	79.78	79.97	80.15	80.41
PZ-8	81.42	--	82.24	--	80.23	--	80.04	--	80.47
PZ-9	80.64	79.09	79.59	79.60	80.19	79.15	79.62	79.63	80.26
PZ-10	81.63	78.91	78.97	79.21	79.17	79.21	79.04	79.52	79.62
Staff Gauges									
MMB-PZ1	82.60	--	--	--	81.89	--	--	--	--
MMB-PZ2	81.89	--	--	--	80.63	--	--	--	--

Notes:

ft AMSL - feet Above Mean Sea Level

TABLE 4.8

GROUNDWATER INDICATOR SAMPLING SUMMARY(1)
WILMINGTON FACILITY

Monitoring Well ID	*Date Sampled (mm/dd/yy)*	*Monitoring Well ID*	*Date Sampled (mm/dd/yy)*
GW-3D	08/01/91	GW-45S	02/08/92
GW-3S	08/01/91	GW-45D	12/13/92
GW-4S	08/01/91	GW-46D	02/08/92
GW-4D	08/01/91	GW-47	08/01/91
GW-10D	08/01/91	GW-48D	08/01/91
GW-10S	08/01/91	GW-48S	08/01/91
GW-11S	08/01/91	GW-50D	08/01/91
GW-12S	08/01/91	GW-50S	08/01/91
GW-17D	08/01/91	GW-51D	08/01/91
GW-17S	08/01/91	GW-51S	08/01/91
GW-18D	08/01/91	GW-52D	08/01/91
GW-21D	08/01/91	GW-52S	08/01/91
GW-21S	08/01/91	GW-53D	08/01/91
GW-24S	08/01/91	GW-53S	08/01/91
GW-25S	08/01/91	GW-54D	08/01/91
GW-26S	08/01/91	GW-54S	08/01/91
GW-28D	08/01/91	GW-55D	08/01/91
GW-28S	08/01/91	GW-55S	08/01/91
GW-29D	08/01/91	GW-56D	08/01/91
GW-29S	08/01/91	GW-56S	08/01/91
GW-36D	08/01/91	GW-57D	02/08/92,05/13/92
GW-37D	08/01/91	GW-59D	02/08/92
GW-38D	08/01/91	GW-59S	02/08/92
GW-39D	08/01/91	GW-60D	05/13/92
GW-40D	08/01/91	GW-60S	05/13/92
GW-40S	08/01/91	GW-61D	05/12/92
GW-42D	08/01/91	GW-61S	05/13/92
GW-42S	08/01/91	GW-62D	05/12/92
GW-43D	08/01/91	GW-62M	05/12/92
GW-43S	08/01/91	GW-62S	05/12/92
GW-44D	01/27/92		

Notes:

(1) Indicator parameters include chloride, chromium, ammonia and sulphate.

TABLE 4.9

FULL GROUNDWATER TCL/TAL PARAMETER SAMPLING SUMMARY (1)
WILMINGTON FACILITY

Monitoring Well ID	*Date Sampled (mm/dd/yy)*
IW-11	12/17/91
GW-27D	12/10/91
GW-31D	12/06/91
GW-35S	12/10/91
GW-36	12/10/91
GW-40D	12/10/91
GW-42D	12/10/91
GW-50D	12/10/91
GW-54S	12/06/91
GW-55D	12/10/91
SL-05	12/10/91

Notes:

(1) Samples also analyzed for 2,4,4-Trimethyl-1-Pentene, 2,4,4-Trimethyl-2-Pentene, Ammonia, Chlorides and Sulphates.

TABLE 4.10

FIRST ROUND GROUNDWATER SAMPLING SUMMARY
WILMINGTON FACILITY

First Round Groundwater Sampling (August 3 - 13, 1992)

Monitoring Well I.D.	*pH*	*Conductivity (μhmos)*	*Temperature (°C)*	*Sample Identification*	*Analysis Parameters*
GW Monitoring Wells					
GW-4	6.1	900	14	W-920804-JM-029	SSPL
GW-4D	6.2	1,300	14	W-920804-JM-028	SSPL
GW-6S	--	--	--	W-920804-JM-013	SSPL
GW-6D	6.4	600	15	W-920804-JM-014	SSPL
GW-10S	4.3	100	15	W-920810-JM-071	SSPL
GW-10D	4.2	9,400	14	W-920810-JM-059	SSPL
GW-12	5.6	200	15	W-920810-JM-067	SSPL
GW-17S	--	--	--	DRY	--
GW-17D	5.5	2,350	15	W-920805-JM-024	SSPL
GW-18S	--	--	--	DRY	--
GW18D	7.0	700	15	W-920806-JM-049	SSPL
GW-19D	6.4	2,000	15	W-920804-JM-015	SSPL
GW-22S	--	--	--	W-920812-JM-109	SSPL
GW-22D	--	--	--	W-920812-JM-110	SSPL
GW-25	7.1	3,800	13	W-920810-JM-068	SSPL
GW-26	6.2	900	16	W-920810-JM-072	SSPL
GW-27S	6.5	2,600	15	W-920812-JM-093	SSPL and Density
GW-27D	3.7	>19,900	15	W-920812-JM-094	SSPL and Density
GW-28S	6.2	300	21	W-920810-JM-064	SSPL
GW-28D	6.3	500	21	W-920810-JM-063	SSPL
GW-29S	3.9	200	18	W-920810-JM-061	SSPL
GW-29D	6.1	3,000	16	W-920810-JM-060	SSPL
GW-30DR	4.0	>50,000	20	W-920803-JM-020	SSPL
GW-31S	6.5	295	17.5	W-920803-JM-002	SSPL
GW-31D	6.8	400	15	W-920803-JM-001	SSPL
GW-32S	6.1	335	17	W-920803-JM-004	SSPL
GW-32D	7.0	1,550	16.5	W-920803-JM-003	SSPL
GW-33S	6.6	255	16.5	W-920803-JM-007	SSPL
GW-33D	6.8	700	17	W-920803-JM-008	SSPL
GW-34S	6.8	130	17	W-920804-JM-010	SSPL
GW-34D	4.6	4,300	16	W-920804-JM-009	SSPL
GW-35S	6.5	1,600	18	W-920804-JM-012	SSPL
GW-35D	4.0	>50,000	18	W-920804-JM-011	SSPL
GW-36	3.5	>19,900	13	W-920811-JM-082	SSPL and Hex
GW-37	3.5	>19,900	13	W-920811-JM-083	SSPL and Hex
GW-38	4.1	28,000	18	W-920804-JM-021	SSPL
GW-39	6.0	800	17	W-920806-JM-058	SSPL
GW-40D	9.0	2,400	13	W-920811-JM-084/085 DUP/086 MS/087 MSD	SSPL and Density
GW-40S	4.9	100	16	W-920811-JM-088	SSPL
GW-42D	3.7	>50,000	20	W-920805-JM-025/026 DUP/033 MS/032 MSD	SSPL, Hex and Density

TABLE 4.10

FIRST ROUND GROUNDWATER SAMPLING SUMMARY
WILMINGTON FACILITY

First Round Groundwater Sampling (August 3 - 13, 1992)

Monitoring Well I.D.	*pH*	*Conductivity (μhmos)*	*Temperature (°C)*	*Sample Identification*	*Analysis Parameters*
GW-42S	5.3	220	19	W-920805-JM-027	SSPL
GW-43D	4.3	24,000	18	W-920805-JM-036/037 DUP	SSPL, Hex and Density
GW-43S	6.0	300	15	W-920805-JM-038	SSPL and Density
GW-44D	3.5	41,000	20	W-920812-JM-108	SSPL, Hex and Density
GW-44S	7.1	200	17	W-920812-JM-107	SSPL and Density
GW-45D	3.4	>10,000	--	W-920810-JM-062	SSPL, Hex and Density
GW-45S	6.2	390	--	W-920810-JM-046	SSPL
GW-46D	6.9	200	12.5	W-920811-JM-075	SSPL
GW-47	--	--	--	W-920813-JM-113	SSPL
GW-48D	5.8	100	11	W-920812-JM-092/090 MS/089MSD	SSPL
GW-48S	4.6	100	13	W-920812-JM-091	SSPL
GW-49D	6.1	700	15	W-920812-JM-104	SSPL
GW-50D	6.1	10,500	12	W-920805-JM-030/031 DUP/034 MS/035 MSD	SSPL
GW-50S	5.8	2,200	13.0	W-920806-JM-045	SSPL and Density
GW-51D	5.9	1,000	12	W-920805-JM-022	SSPL
GW-51S	5.1	700	13	W-920805-JM-023	SSPL
GW-52D	--	--	--	W-920804-JM-019	SSPL
GW-52S	7.8	800	17	W-920804-JM-018	SSPL
GW-53D	6.4	390	16	W-920804-JM-016	SSPL
GW-53S	6.8	120	20	W-920804-JM-017	SSPL
GW-54D	5.8	400	20	W-920803-JM-006	SSPL
GW-54S	6.5	290	20	W-920805-JM-005	SSPL
GW-55D	5.7	11,500	16	W-920805-JM-042/039 MS/040 MSD	SSPL
GW-55S	6.3	4,100	18	W-920805-JM-041	SSPL
GW-56D	5.7	1,100	14	W-920806-JM-047	SSPL
GW-56S	4.8	600	15	W-920806-JM-048	SSPL
GW-57D	6.2	450	15	W-920806-JM-051/052 MS/053 MSD	SSPL
GW-58D	6.1	5,300	--	W-920811-JM-079	SSPL, Hex and Density
GW-58S	7.1	340	--	W-920811-JM-078	SSPL and Density
GW-59D	4.1	35,000	20	W-920806-JM-056/055 DUP	SSPL, Hex and Density
GW-59S	6.0	650	19	W-920806-JM-054	SSPL and Density
GW-60D	6.6	200	17	W-920811-JM-081	SSPL
GW-60S	6.4	300	20	W-920811-JM-080	SSPL
GW-61D	6.2	500	13	W-920812-JM-096	SSPL
GW-61S	5.9	300	13	W-920812-JM-095	SSPL
GW-62D	6.3	500	13	W-920811-JM-074	SSPL
GW-62S	6.0	300	15	W-920811-JM-073	SSPL
GW-62M	6.6	200	12	W-920811-JM-106	SSPL
GW-62BR	6.7	6,800	14	W-920813-JM-114	SSPL and Density
GW-63D	7.3	340	--	W-920812-JM-097	SSPL
GW-63S	7.5	310	--	W-920812-JM-098	SSPL
GW-64D	6.5	700	12	W-920812-JM-100/101 DUP	SSPL

TABLE 4.10

FIRST ROUND GROUNDWATER SAMPLING SUMMARY
WILMINGTON FACILITY

First Round Groundwater Sampling (August 3 - 13, 1992)

Monitoring Well I.D.	*pH*	*Conductivity (µhmos)*	*Temperature (°C)*	*Sample Identification*	*Analysis Parameters*
GW-64S	5.8	200	18	W-920812-JM-099	SSPL
GW-65D	6.5	300	12	W-920813-JM-111	SSPL
GW-65S	6.4	300	13	W-920813-JM-112	SSPL
GW-66D	7.1	300	–	W-920811-JM-077	SSPL
GW-66S	7.1	200	–	W-920811-JM-076	SSPL
GW-68D	6.1	450	17	W-920806-JM-050	SSPL
GW-69D	4.2	14,500	16	W-920806-JM-044	SSPL
GW-69S	5.8	200	17.5	W-920806-JM-043	SSPL
GW-70D	5.5	>10,000	–	W-920810-JM-069	SSPL
GW-70S	6.5	350	–	W-920810-JM-070	SSPL
Sulfate Landfill Monitoring Wells					
SL1S	5.2	100	18	W-920810-JM-065	SSPL
SL1D	5.2	200	17	W-920810-JM-066	SSPL
SL6	5.4	2,000	18	W-920806-JM-057	SSPL
Other Plant Wells					
B-3	–	–	–	W-920812-JM-103	SSPL
IW-4	–	–	–	W-920812-JM-102	SSPL
IW-11	–	–	–	W-920812-JM-105	SSPL

Notes:

SSPL include TCL VOCs, SVOCs, Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate.
Hex analysis parameter is hexavalent chromium
Duplicate (DUP)
Matrix Spike (MS)
Matrix Spike Duplicate (MSD)

TABLE 4.11

SECOND ROUND GROUNDWATER SAMPLING SUMMARY
WILMINGTON FACILITY

(1)

Second Round Groundwater Sampling (November 3 - 19, 1992)

Monitoring Well I.D.	*pH*	*Conductivity (µmhos)*	*Temperature (°C)*	*Sample Identification*	*Analysis Parameters*
GW Monitoring Wells					
GW-3S	6.2	267	11.2	W-921105-JM-035	SSPL
GW-3D	6.4	624	10.1	W-921105-JM-034	SSPL
GW-4S	6.2	578	11.9	W-921105-JM-043	SSPL
GW-4D	6.3	699	11.4	W-921105-JM-042	SSPL
GW-6S	6.5	464	12.5	W-921103-JM-022	SSPL
GW-6D	6.7	464	11.5	W-921103-JM-021	SSPL
GW-10S	5.1	165	11.4	W-921112-JM-094	SSPL
GW-10D	5.1	5,670	9.7	W-921109-JM-061	SSPL
GW-11	6.6	2,070	10.8	W-921109-JM-059	SSPL
GW-12	6.6	114	12.0	W-921111-JM-074	SSPL
GW-17S	6.7	686	10.8	W-921103-JM-018	SSPL
GW-17D	5.5	1,880	11.3	W-921103-JM-017	SSPL
GW-18S	--	–	–	Dry	SSPL
GW-18D	7.1	673	8.1	W-921109-JM-056	SSPL
GW-19D	6.8	1,340	10.0	W-921109-JM-050/053 DUP/051 MS/052 MSD	SSPL
GW-21S	6.9	314	13.1	W-921106-JM-044	SSPL
GW-21D	7.0	235	12.4	W-921106-JM-045	SSPL
GW-22S	6.8	819	13.7	W-921105-JM-038	SSPL
GW-22D	4.1	21,400	11.4	W-921105-JM-039	SSPL
GW-25	7.3	1,293	11.4	W-921116-JM-108	SSPL
GW-26	6.54	410	11.7	W-921116-JM-099	SSPL
GW-27S	7.1	1,987	11.5	W-921109-JM-057	SSPL and Density
GW-27D	4.4	15,200	10.0	W-921109-JM-058	SSPL and Density
GW-28S	5.7	344	11.5	W-921106-JM-049	SSPL
GW-28D	6.8	416	11.6	W-921106-JM-048	SSPL
GW-29S	5.7	270	10.6	W-921106-JM-046	SSPL
GW-29D	6.4	1,850	10.2	W-921106-JM-047	SSPL
GW-30DR	4.2	26,300	10.3	W-921109-JM-062	SSPL
GW-31S	6.5	205	-	W-921102-JM-001	SSPL
GW-31D	6.7	305	-	W-921102-JM-002	SSPL
GW-32S	7.0	105	-	W-921102-JM-003	SSPL
GW-32D	6.8	237	-	W-921102-JM-004	SSPL
GW-33S	7.0	NT	NT	W-921103-JM-019	SSPL
GW-33D	7.2	503	NT	W-921103-JM-020	SSPL
GW-34S	6.1	150	14.6	W-921105-JM-040	SSPL
GW-34D	4.8	2,850	13.4	W-921105-JM-041	SSPL
GW-35S	6.7	1,490	13.5	W-921105-JM-037	SSPL
GW-35D	3.8	5,940	11.8	W-921105-JM-036	SSPL
GW-36	4.1	27,800	9.9	W-921116-JM-101	SSPL and Hex
GW-37	4.24	26,300	9.6	W-921116-JM-100	SSPL and Hex
GW-38	4.4	12,800	10.4	W-921109-JM-060	SSPL
GW-39	6.6	324	11.2	W-921111-JM-077	SSPL
GW-40D	9.0	1,480	10.4	W-921111-JM-069/075 MS/076 MSD	SSPL and Density
GW-40S	5.3	86	127	W-921111-JM-078	SSPL
GW-42D	3.8	36,000	11.5	W-921111-JM-079/082 DUP/080 MS/081 MSD	SSPL, Hex and Density
GW-42S	5.8	125	13.2	W-92111-JM-083	SSPL
GW-43D	4.5	1,409	11.0	W-921111-JM-065/066 DUP	SSPL, Hex and Density
GW-43S	6.1	222	12.7	W-921111-JM-084	SSPL and Density

TABLE 4.11

SECOND ROUND GROUNDWATER SAMPLING SUMMARY
WILMINGTON FACILITY

(1)

Second Round Groundwater Sampling (November 3 - 19, 1992)

Monitoring Well I.D.	*pH*	*Conductivity (µmhos)*	*Temperature (°C)*	*Sample Identification*	*Analysis Parameters*
GW-44D	3.2	28,700	10.5	W-921110-JM-063	SSPL, Hex and Density
GW-44S	5.2	156	11.9	W-921110-JM-071	SSPL and Density
GW-45D	4.0	20,700	10.8	W-921112-JM-093	SSPL, Hex and Density
GW-45S	5.7	228	13.1	W-921112-JM-092	SSPL
GW-46D	6.6	118	10.6	W-921117-JM-114	SSPL
GW-47	6.34	56	12.1	W-921118-JM-128	SSPL
GW-48D	6.32	114	10.0	W-921117-JM-115/116 MS/117 MSD	SSPL
GW-48S	5.49	72	12.3	W-921117-JM-118	SSPL
GW-49D	6.7	355	13.2	W-921116-JM-102	SSPL
GW-50D	6.3	7,470	9.8	W-921104-JM-023/025 DUP/024 MS/026 MSD	SSPL
GW-50S	6.2	1,382	11.2	W-921104-JM-027	SSPL and Density
GW-51D	6.0	1,230	10.6	W-921103-JM-016	SSPL
GW-51S	6.0	502	11.0	W-921103-JM-015	SSPL
GW-52D	9.3	1,570	12.7	W-921103-JM-010	SSPL
GW-52S	7.9	662	13.0	W-921103-JM-009	SSPL
GW-53D	6.8	236	15.1	W-921103-JM-011	SSPL
GW-53S	8.1	68	14.2	W-921103-JM-012	SSPL
GW-54D	6.5	257	15.5	W-921103-JM-013	SSPL
GW-54S	6.7	170	14.1	W-921103-JM-014	SSPL
GW-55D	5.9	9,150	11.4	W-921102-JM-006	SSPL
GW-55S	6.1	3,520	11.1	W-921102-JM-005	SSPL
GW-56D	5.9	404	10.1	W-921102-JM-008	SSPL
GW-56S	5.3	322	10.4	W-921102-JM-007	SSPL
GW-57	6.52	156	10.0	W-921117-JM-110/109 MS/113 MSD	SSPL
GW-58D	6.3	3,990	10.9	W-921119-JM-091	SSPL, Hex and Density
GW-58S	6.2	224	11.9	W-921112-JM-090	SSPL and Density
GW-59D	3.4	21,600	9.5	W-921110-JM-64/067 DUP	SSPL, Hex and Density
GW-59S	5.3	302	13.6	W-921110-JM-070	SSPL and Density
GW-60D	6.7	123	10.6	W-921117-JM-112	SSPL
GW-60S	6.8	115	8.7	W-921117-JM-111	SSPL
GW-61D	6.5	312	9.7	W-921113-JM-096	SSPL
GW-61S	6.4	167	10.6	W-921113-JM-095	SSPL
GW-61BR	NT	500	NT	W-921218-JM-133	SSPL
GW-62D	6.64	60	9.2	W-921116-JM-103	SSPL
GW-62S	6.53	49.0	10.9	W-921116-JM-105	SSPL
GW-62M	6.75	40	8.8	W-921116-JM-104	SSPL
GW-62BR	7.71	2,940	8.1	W-921119-JM-129	SSPL and Density
GW-62BRD	NT	NT	NT	W-930107-JM-134	SSPL
GW-63D	6.62	236	10.6	W-921118-JM-122	SSPL
GW-63S	6.49	170	9.3	W-921118-JM-121	SSPL
GW-64D	6.8	356	8.0	W-921118-JM-127	SSPL
GW-64S	6.09	125	13.6	W-921118-JM-126	SSPL
GW-65D	6.8	190	8.8	W-921118-JM-123	SSPL
GW-65S	6.61	1.0	10.8	W-921118-JM-124/125 DUP	SSPL
GW-66D	6.6	530	9.9	W-921112-JM-089	SSPL
GW-66S	6.6	146	10.7	W-921112-JM-088	SSPL
GW-67S	6.6	97	11.1	W-921113-JM-097	SSPL
GW-67D	6.9	316	10.9	W-921113-JM-098	SSPL
GW-68BR	NT	500	--	W-921218-JM-133	SSPL
GW-68	5.9	198	14.9	W-921114-JM-085	SSPL

TABLE 4.11

SECOND ROUND GROUNDWATER SAMPLING SUMMARY
WILMINGTON FACILITY

(1)
Second Round Groundwater Sampling (November 3 - 19, 1992)

Monitoring Well I.D.	*pH*	*Conductivity (µmhos)*	*Temperature (°C)*	*Sample Identification*	*Analysis Parameters*
GW-69D	4.1	7,500	9.2	W-921116-JM-106	SSPL
GW-69S	5.46	117	11.6	W-921116-JM-107	SSPL
GW-70D	5.6	1,356	10.4	W-921112-JM-087	SSPL
GW-70S	6.5	206	11.5	W-921112-JM-086	SSPL
GW-71S	NT	100	NT	W-921217-JM-130	SSPL
GW-71D	NT	500	NT	W-921217-JM-131	SSPL
GW-72D	7.11	121	13.1	W-921117-JM-120	SSPL
GW-73D	6.5	300	7.0	W-930420-MJ-003	SSPL
GW-73S	6.4	100	7.0	W-930420-MJ-004	SSPL
GW-74D	6.4	400	8.0	W-930420-MJ-001	SSPL
GW-74S	6.4	300	8.0	W-930420-MJ-002	SSPL
GW-75D	6.8	250	10.0	W-930507-JM-01/MS/MSD	SSPL
GW-75S	6.8	200	8.0	W-930507-JM-02	SSPL
Sulphate Landfill					
SL1D	6.3	194	12.2	W-921109-JM-055	SSPL
SL6	6.1	2,822	11.3	W-921109-JM-054	SSPL
Other Plant Wells					
B-3	5.0	8.54	12.8	W-921110-JM-072	SSPL
IW-4	5.4	4.75	12.5	W-921110-JM-068	SSPL
IW-11	--	--	--	W-921110-JM-073	SSPL
BR-1	13.31	8,590	9.0	W-921119-JM-119	SSPL

Notes:

(1) Sampling conducted on monitoring wells installed after November 19, 1992 have been included as part of the Second Round Groundwater Sampling Event.
SSPL include TCL VOCs, SVOCs, Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate.
Hex analysis parameter is hexavalent chromium.
Duplicate (DUP).
Matrix Spike (MS).
Matrix Spike Duplicate (MSD).

TABLE 4.12

FIRST ROUND SURFACE WATER SAMPLING SUMMARY
WILMINGTON FACILITY

First Round Surface Water (August 31 - September 2, 1992)

Location I.D.	*pH*	*Conductivity (µhmos)*	*Temperature (°C)*	*Sample Identification*	*Analysis Parameters*
SW-1	7.40	318	20.7	W-920831-JM-120	SSPL
SW-2	7.52	332	21.3	W-920831-JM-119	SSPL
SW-3	7.51	380	23.2	W-920831-JM-118	SSPL
SW-4	7.37	381	24.5	W-920831-JM-117	SSPL
SW-5	6.22	389	25.0	W-920831-JM-115	SSPL
SW-6	6.67	1,235	20.6	W-920831-JM-116	SSPL
SW-7	6.20	1,685	16.5	W-920901-JM-121	SSPL
SW-8	7.10	1,497	22.2	W-920901-JM-122	SSPL
SW-9	7.10	1,366	19.7	W-920901-JM-123	SSPL
SW-10	7.30	1,382	19.0	W-920901-JM-125	SSPL
SW-11	7.00	1,489	19.8	W-920901-JM-124	SSPL
SW-12	6.80	1,160	19.4	W-920902-JM-133	SSPL
SW-13	6.60	1,252	18.6	W-920902-JM-132	SSPL
SW-14	6.40	1,151	20.9	W-920901-JM-126	SSPL
SW-15	5.70	1,375	19.5	W-920902-JM-136	SSPL
SW-16	5.00	3,980	25.7	W-920902-JM-135	SSPL
SW-17	5.10	2,000	20.7	W-920901-JM-127/128 DUP/ 129 MS/130 MSD/131RB	SSPL & Hex
SW-18	5.80	364	23.0	W-920902-JM-134	SSPL
SW-19	–	–	–	DRY	–
SW-20	–	–	–	DRY	–
SW-21	–	–	–	DRY	–
SW-22	–	–	–	DRY	–

Notes:

SSPL include TCL VOCs, SVOCs, Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate.
Hex analysis parameter is hexavalent chromium.
Duplicate (DUP).
Matrix Spike (MS).
Matrix Spike Duplicate (MSD).

TABLE 4.13

SECOND ROUND SURFACE WATER SAMPLING SUMMARY
WILMINGTON FACILITY

Second Round Surface Water (November 30, 1992 - January 7, 1993) (1)

Location I.D.	*pH*	*Conductivity (µhmos)*	*Temperature (°C)*	*Sample Identification*	*Analysis Parameters*
SW-1	6.7	400	9.3	W-921130-MJ-004	SSPL
SW-2	6.4	400	9.0	W-921130-MJ-003	SSPL
SW-3	6.5	400	9.2	W-921130-MJ-005	SSPL
SW-4	6.3	400	9.1	W-921130-MJ-002	SSPL
SW-5	6.0	400	9.3	W-921130-MJ-001	SSPL
SW-6	7.1	1,600	7.5	W-921201-MJ-017/018 DUP/ 019 MS/020 MSD	SSPL & Hex
SW-7	6.3	1,200	5.8	W-921201-MJ-009	SSPL
SW-8	7.1	1,500	6.0	W-921201-MJ-014	SSPL
SW-9	6.5	1,600	8.2	W-921201-MJ-012	SSPL
SW-10	6.7	1,700	8.6	W-921201-MJ-010	SSPL
SW-11	6.7	1,700	9.1	W-921201-MJ-011	SSPL
SW-12	7.0	1,600	12.3	W-921201-MJ-016	SSPL
SW-13	7.6	1,000	9.5	W-921201-MJ-013	SSPL
SW-14	6.5	1,800	10.4	W-921201-MJ-015	SSPL
SW-15	6.1	1,500	10.3	W-921202-MJ-028	SSPL
SW-16	5.2	4,200	9.1	W-921202-MJ-027	SSPL & Hex
SW-17	6.0	600	2.8	W-921202-MJ-021/022 DUP/ 023 MS/024 MSD	SSPL & Hex
SW-18	5.5	300	6.0	W-921202-MJ-025	SSPL
SW-19	6.5	NR	7.0	W-921203-MJ-029	SSPL
SW-20	4.7	400	6.8	W-921201-MJ-008	SSPL
SW-21	4.8	400	5.6	W-921201-MJ-007	SSPL
SW-22	5.1	300	6.0	W-921201-MJ-006	SSPL
SW-23	6.7	1,000	5.3	W-921202-MJ-026	SSPL & Hex
SW-24	NR	NR	NR	W-930107-JM-135	SSPL
SW-25	7.0	800	3.0	W-930325-JM-01	SSPL
SW-26	7.0	850	4.0	W-930325-JM-02	SSPL
SW-27	6.8	600	4.0	W-930325-JM-03	SSPL
SW-28	7.2	500	3.0	W-930325-JM-04	SSPL
SW-29	6.1	400	12.0	W-930420-MJ-005	SSPL
SW-30	6.1	400	12.0	W-930420-MJ-006	SSPL

Notes:

(1) Sampling conducted at locations after January 7, 1993 have been included as part of the Second Round Surface Water Sampling Event.
SSPL include TCL VOCs, SVOCs, Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate.
Hex analysis parameter is hexavalent chromium.
Duplicate (DUP).
Matrix Spike (MS).
Matrix Spike Duplicate (MSD).

TABLE 4.14

FIRST ROUND SEDIMENT SAMPLING SUMMARY
WILMINGTON FACILITY

First Round Sediment Sampling (August 31 - September 2, 1992)

Location I.D.	*Sample Identification*	*Analysis Parameters*
SW-1	SED-920831-MJ-006	SSPL
SW-2	SED-920831-MJ-005	SSPL
SW-3	SED-920831-MJ-004	SSPL
SW-4	SED-920831-MJ-003	SSPL
SW-5	SED-920831-MJ-001	SSPL
SW-6	SED-920831-MJ-002	SSPL
SW-7	SED-920901-MJ-007	SSPL
SW-8	SED-920901-MJ-012	SSPL
SW-9	SED-920901-MJ-011	SSPL
SW-10	SED-920901-MJ-014	SSPL
SW-11	SED-920901-MJ-013	SSPL
SW-12	SED-920902-MJ-021	SSPL
SW-13	SED-920902-MJ-020	SSPL
SW-14	SED-920901-MJ-015	SSPL
SW-15	SED-920902-MJ-025	SSPL
SW-16	SED-920902-MJ-024	SSPL
SW-17	SED-920901-MJ-016/017 DUP/ 018 MS/019 MSD	SSPL & Hex
SW-18	SED-920902-MJ-023	SSPL
SW-19	SED-920902-MJ-022	SSPL
SW-20	SED-920901-MJ-008	SSPL
SW-21	SED-920901-MJ-009	SSPL
SW-22	SED-920901-MJ-010	SSPL

Notes:

SSPL include TCL VOCs, SVOCs, Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate.
Hex analysis parameter is hexavalent chromium.
Duplicate (DUP).
Matrix Spike (MS).
Matrix Spike Duplicate (MSD).

TABLE 4.15

SECOND ROUND SEDIMENT SAMPLING SUMMARY
WILMINGTON FACILITY

Second Round Sediment Sampling (November 30, 1992 - January 7, 1993) (1)

Location I.D.	*Sample Identification*	*Analysis Parameters*
SW-1	SED-921130-MJ-004	SSPL
SW-2	SED-921130-MJ-003	SSPL
SW-3	SED-921130-MJ-005	SSPL
SW-4	SED-921130-MJ-002	SSPL
SW-5	SED-921130-MJ-001	SSPL
SW-6	SED-921201-MJ-017/018 DUP/ 019 MS/020 MSD	SSPL & Hex
SW-7	SED-921201-MJ-009	SSPL
SW-8	SED-921201-MJ-014	SSPL & Hex
SW-9	SED-921201-MJ-012	SSPL
SW-10	SED-921201-MJ-010	SSPL
SW-11	SED-921201-MJ-011	SSPL
SW-12	SED-921201-MJ-016	SSPL
SW-13	SED-921201-MJ-013	SSPL & Hex
SW-14	SED-921201-MJ-015	SSPL
SW-15	SED-921203-MJ-028	SSPL
SW-16	SED-921202-MJ-027	SSPL & Hex
SW-17	SED-921202-MJ-021/022 DUP/ 023 MS/024 MSD	SSPL & Hex
SW-18	SED-921202-MJ-025	SSPL
SW-19	SED-921203-MJ-029	SSPL
SW-20	SED-921201-MJ-008	SSPL
SW-21	SED-921201-MJ-007	SSPL
SW-22	SED-921201-MJ-006	SSPL
SW-23	SED-921202-MJ-026	SSPL & Hex
SW-24	SED-930107-MJ-001	SSPL
SW-25	S-930325-JM-01	SSPL
SW-26	S-930325-JM-02	SSPL
SW-27	S-930325-JM-03	SSPL
SW-29	SED-930420-MJ-001	SSPL
SW-30	SED-930420-MJ-001	SSPL

Notes:

(1) Sampling conducted at locations after January 7, 1993 have been included as part of the Second Round Sediment Sampling Event.

SSPL include TCL VOCs, SVOCs, Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate.

Hex analysis parameter is hexavalent chromium.

Duplicate (DUP).

Matrix Spike (MS).

Matrix Spike Duplicate (MSD).

TABLE 4.16

SUBSURFACE SOIL SAMPLING SUMMARY
WILMINGTON FACILITY

Borehole Location ID	*Depth (ft bgs)*	*Sample Date (mm/dd/yy)*
BH01	6-8	06/05/91
BH02	6-8	06/05/91
BH03	6-8	06/05/91
BH04	6-8	06/06/91
BH05	6-8	06/06/91
BH06	4-6	06/06/91
BH07	4-6	06/06/91
BH08	4-6	06/06/91
BH09	4-6	06/06/91
BH10	4-6	06/06/91
BH11	4-6	06/07/91
BH11	10-12	06/07/91
BH12	4-6	06/10/91
BH13	8-10	06/10/91
BH14	4-6	06/10/91
BH15	8-10	06/10/91
BH16	4-6	06/10/91
BH17	8-10	06/10/91
BH18	4-6	06/10/91
BH19	5-7	06/11/91
BH20	10-12	06/10/91
BH21	8-10	06/10/91
BH22	8-10	06/10/91
BH23	4-6	06/10/91
BH24	4-6	06/10/91
BH25	4-6	06/10/91
BH26	7-9	06/11/91
BH27	4-6	06/11/91
BH28	4-6	06/11/91
BH29	4-6	06/11/91
BH30	8-10	06/11/91
BH31	3-5	06/11/91
BH32	4-6	06/11/91
BH32	4-6	06/11/91
BH33	6-8	06/11/91
BH34	6-8	06/11/91
BH35	6-8	06/11/91
BH36	4-6	02/06/91
BH37	4-6	02/06/91
BH38	3-5	02/06/91
BH39	4-6	02/06/91
BH40	4-6	02/06/91
BH41	10 - 12	11/02/92

<u>Notes:</u>

ft bgs - feet below ground surface

TABLE 4.17

SURFACE SOIL SAMPLING SUMMARY
WILMINGTON FACILITY

	Surface Soil Location	Sample Date (mm/dd/yy)	Analysis
<u>Grid Locations</u>			
AREA 01			
	SE Corner	07/08/91	SSPL
	SW Corner	07/08/91	
	NW Corner	07/08/91	
	NE Corner	07/08/91	
AREA 02			
	SE Corner	07/09/91	SSPL
	SW Corner	07/09/91	
	NW Corner	07/09/91	
	NE Corner	07/09/91	
AREA 03			
	SE Corner	07/09/91	SSPL
	SW Corner	07/09/91	
	NW Corner	07/09/91	
	NE Corner	07/09/91	
AREA 04			
	SE Corner	07/09/91	SSPL
	SW Corner	07/09/91	
	NW Corner	07/09/91	
	NE Corner	07/09/91	
AREA 05			
	SW Corner	07/09/91	SSPL
	NW Corner	07/09/91	
	NE Corner	07/09/91	
	SE Corner	07/09/91	
AREA 06			
	SW Corner	07/09/91	SSPL
	NW Corner	07/09/91	
	NE Corner	07/09/91	
	SE Corner	07/09/91	
AREA 07			
	SE Corner	07/09/91	SSPL
	SW Corner	07/09/91	
	NW Corner	07/09/91	
	NE Corner	07/09/91	

TABLE 4.17

SURFACE SOIL SAMPLING SUMMARY
WILMINGTON FACILITY

	Surface Soil Location	*Sample Date (mm/dd/yy)*	*Analysis*
AREA 08			
	SE Corner	07/09/91	SSPL
	SW Corner	07/09/91	
	NW Corner	07/09/91	
	NE Corner	07/09/91	
AREA 09			
	Southernmost	07/09/91	SSPL
	2nd Southernmost	07/09/91	
	2nd Northernmost	07/09/91	
	Northernmost	07/09/91	
AREA 10			
	SW Corner	07/09/91	SSPL
	NW Corner	07/09/91	
	NE Corner	07/09/91	
	SE Corner	07/09/91	
Hand Auger Locations			
	SWMU No. 25	05/07/93	SSPL
	SWMU No.27	07/30/91 - 04/22/93	SSPL and Hex
	SWMU No. 30	07/30/91	SSPL
	SWMU No. 33		SSPL
Background Locations			
	BH-41	11/02/92	TCL PAHs, TAL parameters

Notes:

SSPL include TCL VOCs, SVOCs, Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate.
Hex analysis parameter is hexavalent chromium.
TCL PAHs is TCL polynuclear aromatic hydrocarbons.

TABLE 4.18

SUMMARY OF DETECTED PARAMETERS
TOWN WELL SAMPLES
WILMINGTON FACILITY

Parameter/Well	*Butters Row #1*	*Butters Row #1A*	*Town Park*	*Chestnut Street #1*	*Chestnut Street #1A*	*After Treatment*
Volatile Organics (µg/L)						
Vinyl chloride	0.24J	0.37J	ND(0.40)	ND(0.40) / ND(0.40)	ND(0.40)	ND(0.40)
Methylene chloride	1.1B	1.7B	1.7B	1.1B / 1.1B	2.7B	1.7B
trans-1,2-Dichloroethene	0.28	ND(0.17)	ND(0.17)	ND(0.17) / ND(0.17)	ND(0.17)	ND(0.17)
1,1-Dichloroethane	0.20	0.16J	ND(0.18)	ND(0.18) / ND(0.18)	ND(0.18)	ND(0.18)
Cis-1,2-Dichloroethene	33	12	2	5.2 / 5.2	0.21	3.2
Chloroform	ND(0.26)	ND(0.26)	ND(0.26)	ND(0.26) / ND(0.26)	2.6	0.95B
1,2-Dichloroethane	0.10J	ND(0.21)	ND(0.21)	ND(0.21) / ND(0.21)	ND(0.21)	ND(0.21)
Benzene	0.11J	ND(0.39)	ND(0.39)	ND(0.39) / ND(0.39)	ND(0.39)	ND(0.39)
Trichloroethene	1.5	0.22	2.7	5.0 / 4.8	0.51	0.22
Bromodichloromethane	ND(0.20)	ND(0.20)	ND(0.20)	ND(0.20) / ND(0.20)	ND(0.20)	0.61
Dibromochloromethane	ND(0.16)	ND(0.16)	ND(0.16)	ND(0.16) / ND(0.16)	ND(0.16)	0.22
Tetrachloroethene	ND(0.20)	ND(0.20)	0.16J	ND(0.20) / ND(0.20)	ND(0.20)	ND(0.20)
Chlorobenzene	0.24	ND(0.20)	ND(0.20)	ND(0.20) / ND(0.20)	ND(0.20)	ND(0.20)
Napthalene	1.1B	0.46B	0.26JB	0.19JB / 0.10JB	1.2	0.15JB
Priority Pollutant Semivolatile Organics (µg/L)						
Phenol	ND(10)	ND(10)	ND(10)	ND(10) / ND(10)	ND(10)	1J
1,3-Dichlorobenzene	ND(10)	ND(10)	ND(10)	ND(10) / 1J	1J	ND(10)
Diethylphthalate	5J	ND(10)	ND(10)	ND(10) / ND(10)	ND(10)	ND(10)
bis(2-Ethylhexyl)phthalate	ND(10)	ND(10)	ND(10)	12B / ND(10)	3J	ND(10)
Metals (mg/L)						
Aluminum, Total	ND(0.10)	ND(0.10)	0.14	ND(0.10) / ND(0.10)	ND(0.10)	ND(0.10)
Arsenic, Total	0.010	ND(0.005)	ND(0.005)	ND(0.005) / ND(0.005)	ND(0.005)	ND(0.005)
Barium, Total	0.026	0.023	0.026	0.020 / 0.020	0.013	0.014
Copper, Total	0.027	ND(0.025)	ND(0.025)	ND(0.025) / ND(0.025)	ND(0.025)	ND(0.025)
Iron, Total	3.9	7.9	4.0	1.9 / 1.9	0.25	ND(0.025)
Lead, Total	ND(0.005)	ND(0.005)	ND(0.005)	0.006 / ND(0.005)	ND(0.005)	ND(0.005)
Manganese, Total	0.73	0.27	0.48	0.76 / 0.75	0.020	0.015
Sodium, Total	50	37	40	47 / 47	25	36
Zinc, Total	0.028	ND(0.025)	ND(0.025)	0.035 / ND(0.025)	ND(0.025)	ND(0.025)
Other Compounds (mg/L)						
Chloride	74	64	72	71 / 71	41	59
Nitrate as N	ND(0.050)	0.35	0.53	ND(0.050) / 0.18	0.58	ND(0.050)
Nitrite as N	0.050	ND(0.050)	ND(0.050)	ND(0.050) / ND(0.050)	ND(0.050)	ND(0.050)
Nitrogen, Total Kjeldahl as N	2.1	0.45	0.44	0.72 / 0.56	0.60	0.53
Nitrogen-Ammonia as N	2.1	0.35	0.34	0.33 / 0.40	ND(0.10)	ND(0.10)
Sulfate	54	40	27	22 / 31	19	57

Notes:

J - indicates an estimated value - detected at concentrations greater than MDL but less than PQL
B - indicates detection in method blank
/ - indicates results of duplicate analysis

TABLE 5.1

BEDROCK JOINT AND FRACTURE ORIENTATION MEASUREMENTS
WILMINGTON FACILITY

Fracture/Joint Strike (Compass Bearing)	*Dip/Angle*	*Dip Direction*
48°	45°	N
55°	70°	N
5°	40°	N
30°	74°	N
39°	78°	N
40°	88°	N
32°	70°	N
50°	45°	N
50°	65°	N
290°	74°	S
45°	45°	N
35°	70°	S

TABLE 6.1

NATURAL BACKGROUND LEVELS OF METALS IN SOILS FOR THE EASTERN UNITED STATES
WILMINGTON FACILITY

Element	*Range in PPM*	*Reference*	*Notes*
Aluminum - Al	10,000 - 300,000	1,2,5	
Antimony - Sb	1.25 - 10	3,4,5	
Arsenic - As	0.1 - 73	1,2,4,5	
Barium - Ba	10 - 3,000	1,2,4,5	
Beryllium - Be	0.1 - 40	1,2,4,5	
Cadmium - Cd	0.01 - 0.70	1,2,4	A
Chromium - Cr	1 - 1000	1,2,4,5	
Copper - Cu	<1 - 700	1,2,4,5	B
Iron - Fe	7000 - 550,000	1	
Lead - Pb	2 - 300	1,2,4,5	
Lithium - Li	5 - 200	1,2,4	
Magnesium - Mg	600 - 6,000	1,2	
Manganese - Mn	12 - 7,000	1,2,4,5	
Mercury - Hg	0.01 - 3.4	1,2,4,5	C
Nickel - Ni	5 - 700	1,2,4,5	
Potassium - K	50 - 37,000	1,5	
Selenium - Se	0.1 - 3.9	1,2,4,5	
Silver - Ag	0.01 - 5	1,2,4	
Thallium - Tl	no ranges reported		
Vanadium - V	20 - 500	1,2,4	
Zinc - Zn	5 - 2,900	1,2,4,5	

Notes:

A - Cadmium has been reported through many studies in the 1 to 10 ppm range consistantly. NUS QNSH reported 0.27 to 33 ppm with a mean of 6.3; background in New Jersey is reported at 1 to 4 ppm; up to 3 ppm in Somerville (Boynton Yards 21E). It should also be noted that usually less than 10% of the samples have detectable concentrations of Cd.

B - Although given a range in the Eastern US up to 700 ppm, copper by most researchers does not usually exceed 200 ppm, with most reporting 100 ppm or less. For a site in Woburn (Whitney Barrel), with 23 soil samples, copper ranged from 3 to 39 ppm.

C - Mercury is another element that is given a higher natural range (3.4 ppm) for the Eastern US by one researcher (ref. #5) than the others (0.3 ppm). Soils analyzed from QNSY, Boynton Yards, and Whitney Barrel all have reported concentrations of less than 1.0 ppm.

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TABLE 6.2

SPECIFIC GRAVITY ANALYSIS SUMMARY
WILMINGTON FACILITY

Well I.D.	*Specific Gravity (g/mL)* Round 1	*Round 2*
Shallow Monitoring Wells		
GW-27S	1.005	1.022
GW-43S	1.005	1.032
GW-44S	--	1.022
GW-45S	1.005	--
GW-50S	1.016	1.004
GW-58S	0.991	1.005
GW-59S	1.010	1.003
GW-62M	1.000	--
GW-66S	1.023	--
IW-4	0.986	--
Average	1.005	1.015
Deep Monitoring Wells		
GW-27D	1.005	1.052
GW-36	1.091	--
GW-37	1.089	--
GW-40D	0.989/1.008	1.023
GW-42D	1.116/1.10	1.118
GW-43D	1.035/1.015	1.021
GW-44D	1.051	1.083
GW-45D	1.061	1.051
GW-50D	1.015/1.002	--
GW-58D	1.002	1.017
GW-59D	1.068/1.048	1.050
GW-62BR	1.004	1.029
GW-66D	1.004	--
GW-70D	1.044	--
Average	1.039	1.049

B

APPENDIX B

LGI MAGNETOMETER SURVEY REPORT

LGI

A Division of Layne GeoSciences, Inc.

PROJECT #44.2259

GEOPHYSICAL INVESTIGATION

AT THE

OLIN CHEMICAL FACILITY
WILMINGTON, MASSACHUSETTS

PREPARED FOR:

CONESTOGA - ROVERS
651 COLBY DRIVE
WATERLOO, ONTARIO, CANADA N2V1C2

JANUARY 1991

1.0 OVERVIEW

On December 10th-14th, 17th-19th, 1990 and January 7th & 8th, 1991, **LGI**, a division of **Layne GeoSciences, Inc.**, performed a magnetic investigation at the Olin Chemical facility in Wilmington, Massachusetts (see **Site Location Map**). The purpose of the investigation was to locate and delineate the extent of any buried drums and tanks within the two study areas. At the request of the client, a magnetometer survey was selected for the geophysical investigation.

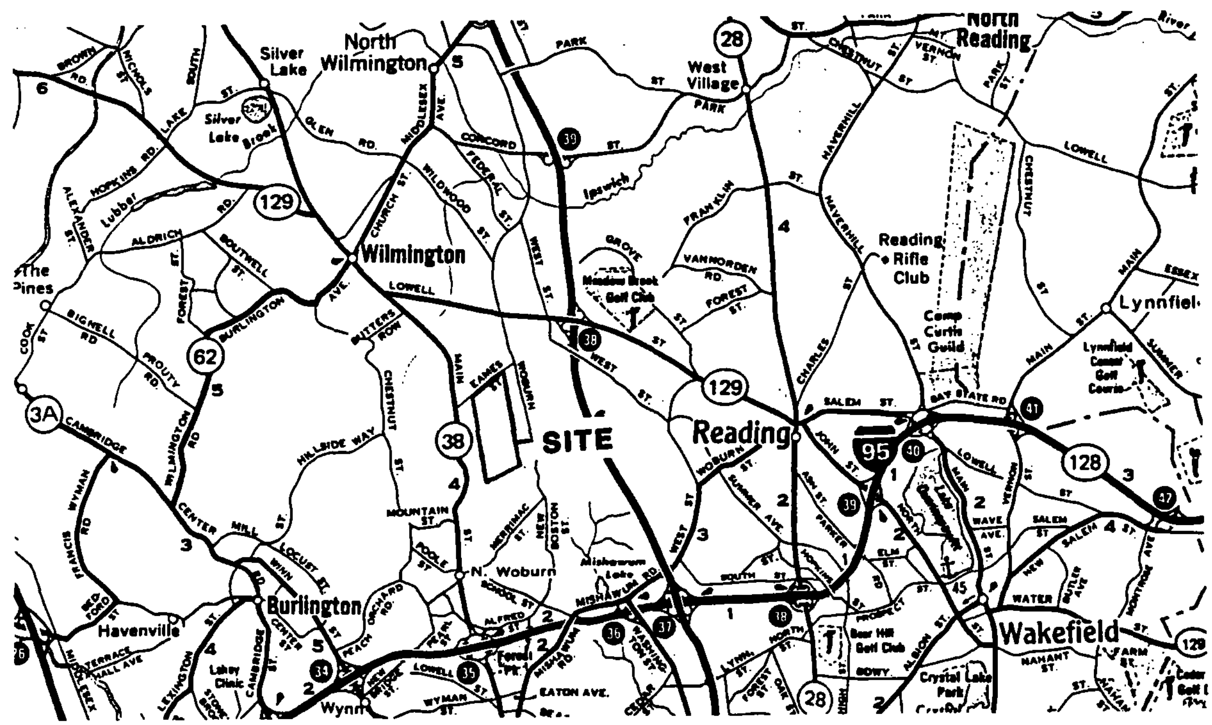


FIGURE 1: Site Location Map

2.0 METHODOLOGY AND FIELD DESIGN

2.1 Theory and Instrumentation

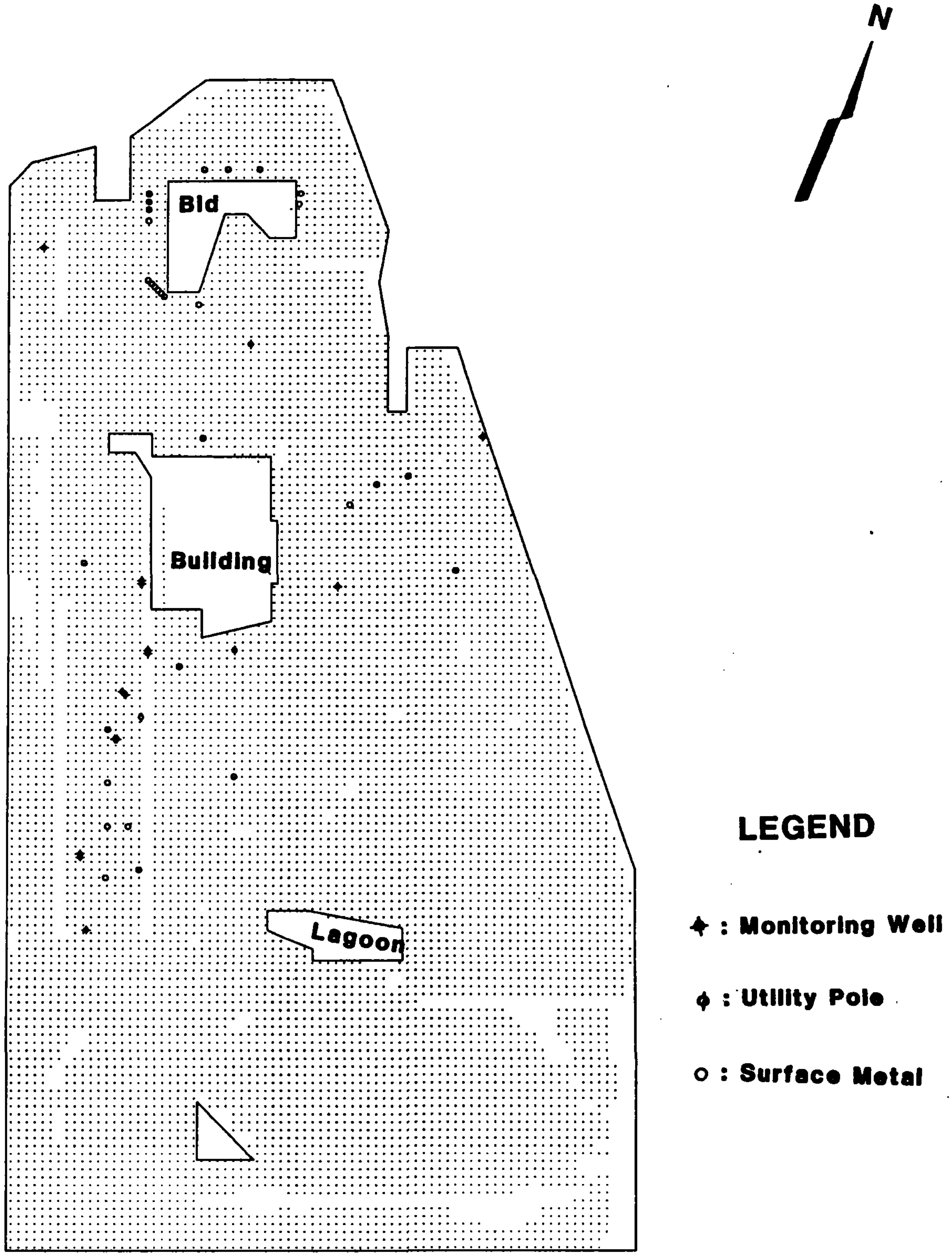
The magnetic method is a non-destructive, non-invasive geophysical technique used to detect local perturbations in the earth's magnetic field caused by buried ferromagnetic objects. A magnetometer is the device utilized to measure the earth's natural magnetic field. The earth's magnetic (geomagnetic) field induces magnetization in magnetically susceptible objects/materials. The presence of such an object in the natural magnetic field alters the field in both magnitude and direction. This induced magnetic field is superimposed on the geomagnetic field, giving rise to regions of anomalous behavior. This behavior is dependent on several variables, including target to sensor distance, target material, target mass, geometry, and orientation.

For this investigation, **LGI** utilized a GEM-2 proton precession dual magnetometer system or gradiometer configuration. The gradiometer system consists of two proton precession magnetometer sensors separated vertically by 56cm. This gradiometer configuration permits an instantaneous determination of the total magnetic field over a fixed vertical distance. The advantages of this technique are the ability determine vertical field gradient while being relatively insensitive to the horizontal gradient component, and eliminates the need to re-occupy a base station. Base station re-occupation is required to correct for natural time varying magnetic field changes (diurnal variations). Because the gradiometer instantaneous differences between two sensors, the effect of the diurnal variation is canceled. The features of this configuration furnish desireable characteristics when exploring for shallow subsurface targets, and not when assisting in geologic structure interpretation.

2.2 Field Design

In total, approximately 9,800 geophysical data points were collected. Two regions, covering a combined area of nearly twenty acres were designated for the gradiometer survey. The two areas encompassed the sulfate landfill, the building and operations area, and the former lagoon area. A 50'x50' control grid was established by a surveyor furnished by the client. **LGI** "filled-in" the control grid to complete a 25'x25' arrangement and data was collected on a 12.5' grid pattern by bisecting the new 25'x25' grid. Locations of scrap, monitoring wells, and other potential sources of magnetic interference were noted by the project geophysicist during the course of data collection (see **Figures 2 & 3**).

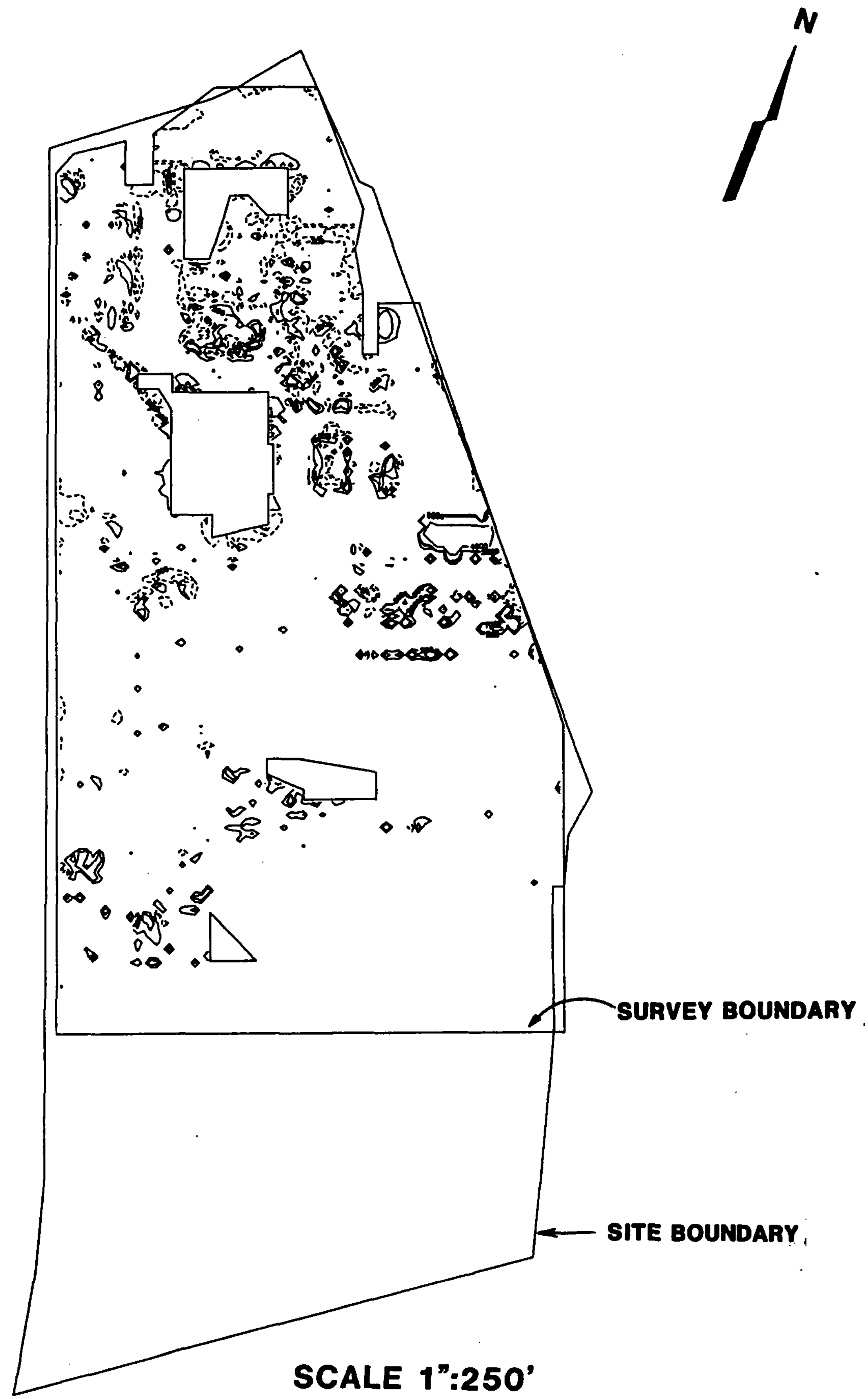
Figure 2:



SCALE 1":200'

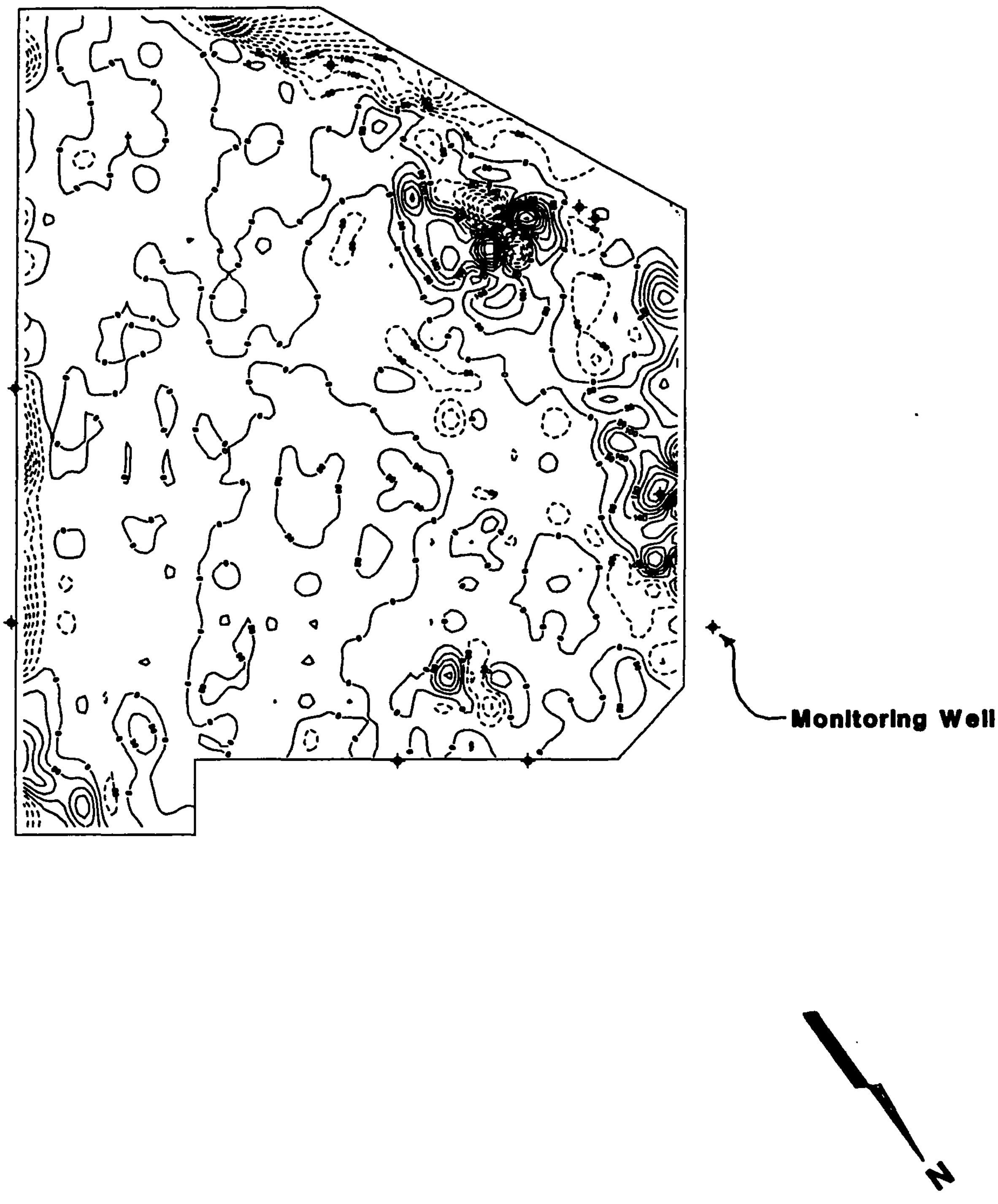
DATA REFERENCE MAP

Figure 7:



MAGNETIC GRADIENT MAP - Filtered for Interpretation

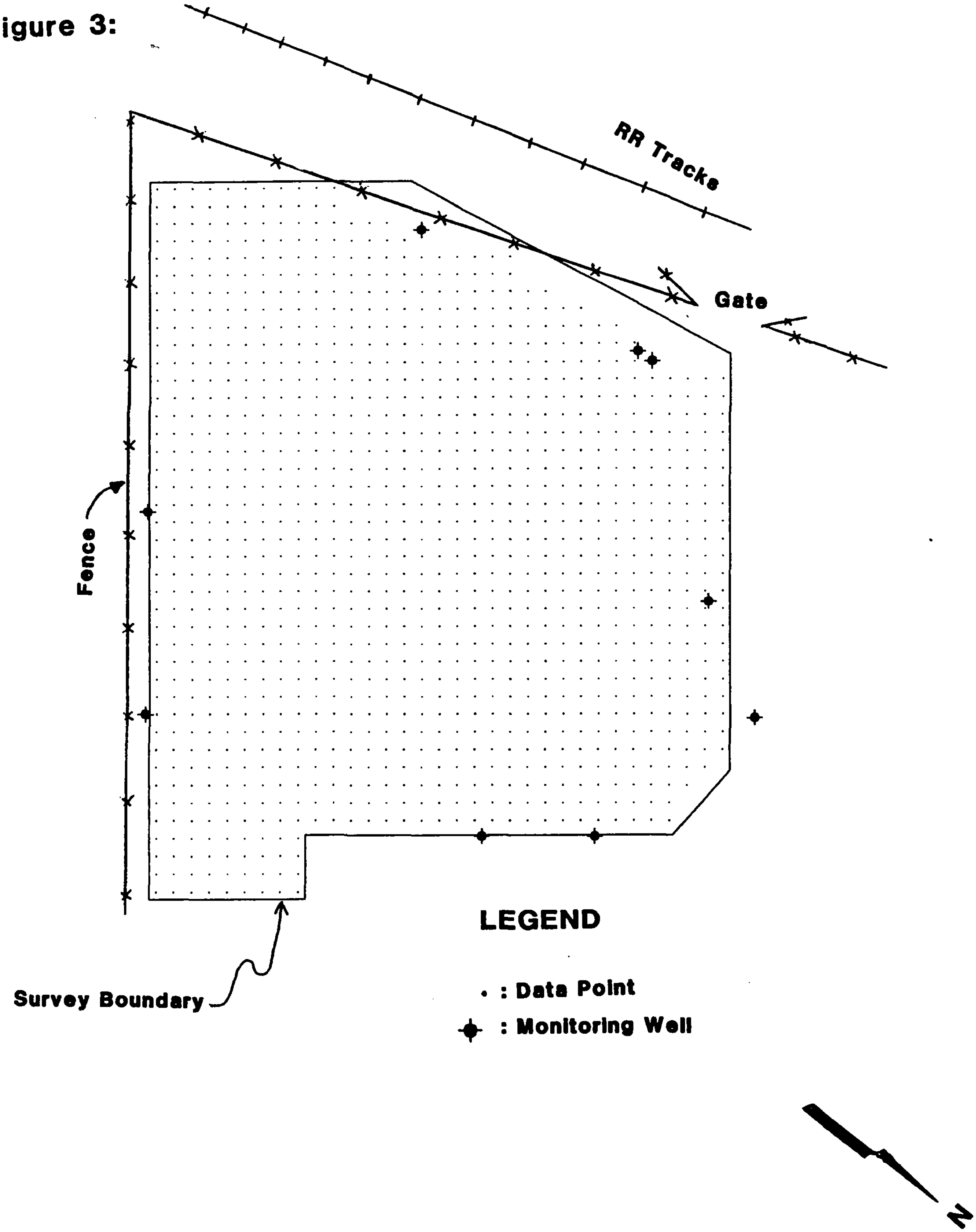
Figure 8:



SCALE 1":100'

MAGNETIC GRADIENT MAP - LANDFILL

Figure 3:



SCALE 1":100'

DATA REFERENCE MAP - LANDFILL

4.0 DATA INTERPRETATION AND RESULTS

Values for the magnetic gradient and the lower magnetometer sensor were recorded by the GEM-2 system and downloaded to a computer. Maps of the Total Magnetic Field and Magnetic Gradient for each area were created by smoothing, filtering, and contouring the data with the aid of a computer (see **Figures 4 - 8**).

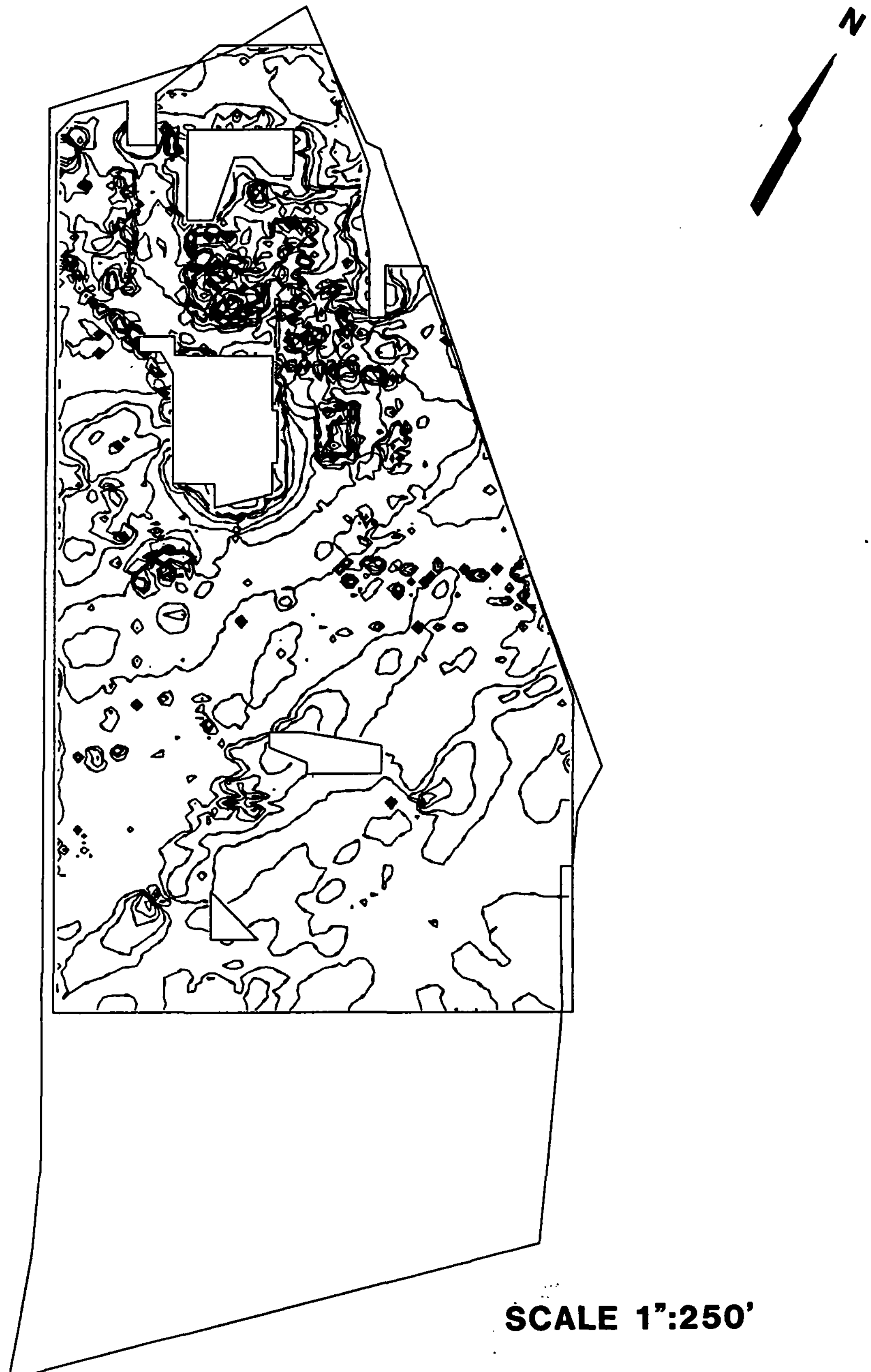
The results of the gradiometer investigation indicated that there are strong anomalous features within the study areas. Interpreted anomalies have been delineated and posted on the **Magnetic Gradient Interpretation Maps**. The following symbol coding scheme has been applied to **Figures 9 & 10**:

Symbol Code	Interpretation
RED Hashed Area	Possible buried drum or group of drums; anomaly shows the characteristics of a large ferromagnetic object.
YELLOW Hashed Area	Buried ferromagnetic object(s); orientation may indicate cultural source.
GREEN Hashed Area	Known feature; scrap at surface, monitoring well, building, etc.

The large anomalies (indicated in **red**) are extremely strong in magnitude implying that the source is relatively shallow (less than 10' deep) and large. **Yellow** anomalies are oriented in a manner that suggests a cultural source (utilities, etc.). These areas should be considered suspicious if no utilities are known to exist in these areas. While the anomalies indicated in **green** surround known features (buildings, foundations, wells, etc.), it does not preclude the existence of drums or other metallic objects buried beneath or in close proximity to the feature. In addition, It was also noted during the course of data collection that magnetic values were influenced while traversing large rock outcrops. Although these effects are relatively minor, they may produce sizeable anomalies.

Due to the presence of strong external magnetic noise in the northern portion of the site, anomalies in this area can only be attributed to the known surface features. Therefore, subsurface features of concern in this area can not be interpreted from the magnetic data alone. **LGI** recommends that these areas, in addition to all yellow and red coded anomalies be investigated further. The ground penetrating radar (GPR) method provides excellent information concerning the size and depth of subsurface features. This geophysical method is also a non-destructive, non-invasive means of examining subsurface targets.

Figure 4:

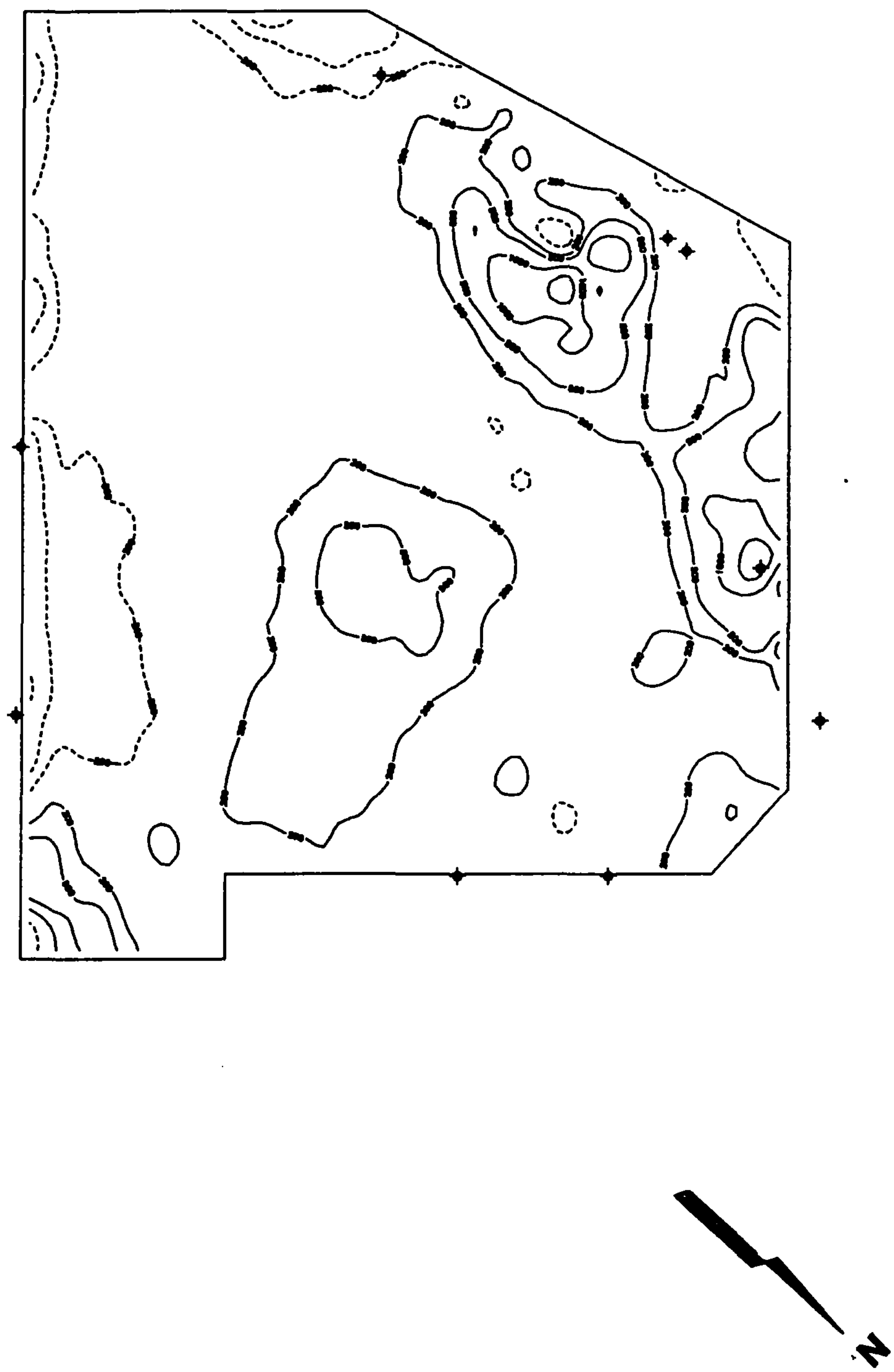


SCALE 1":250'

Values are -55000

TOTAL MAGNETIC FIELD MAP

Figure 5:

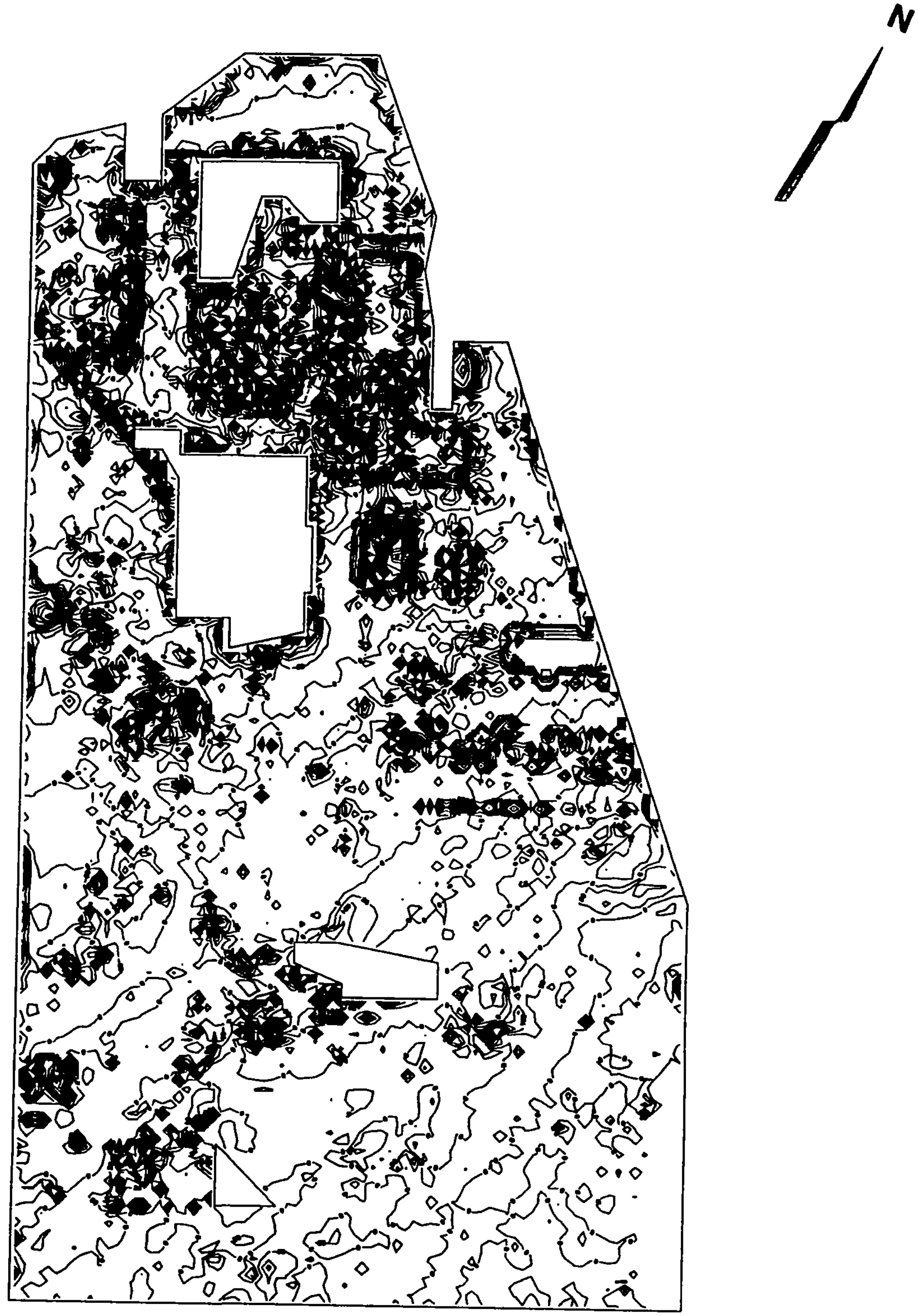


SCALE 1":100'

Values are -55000

TOTAL MAGNETIC FIELD MAP - LANDFILL

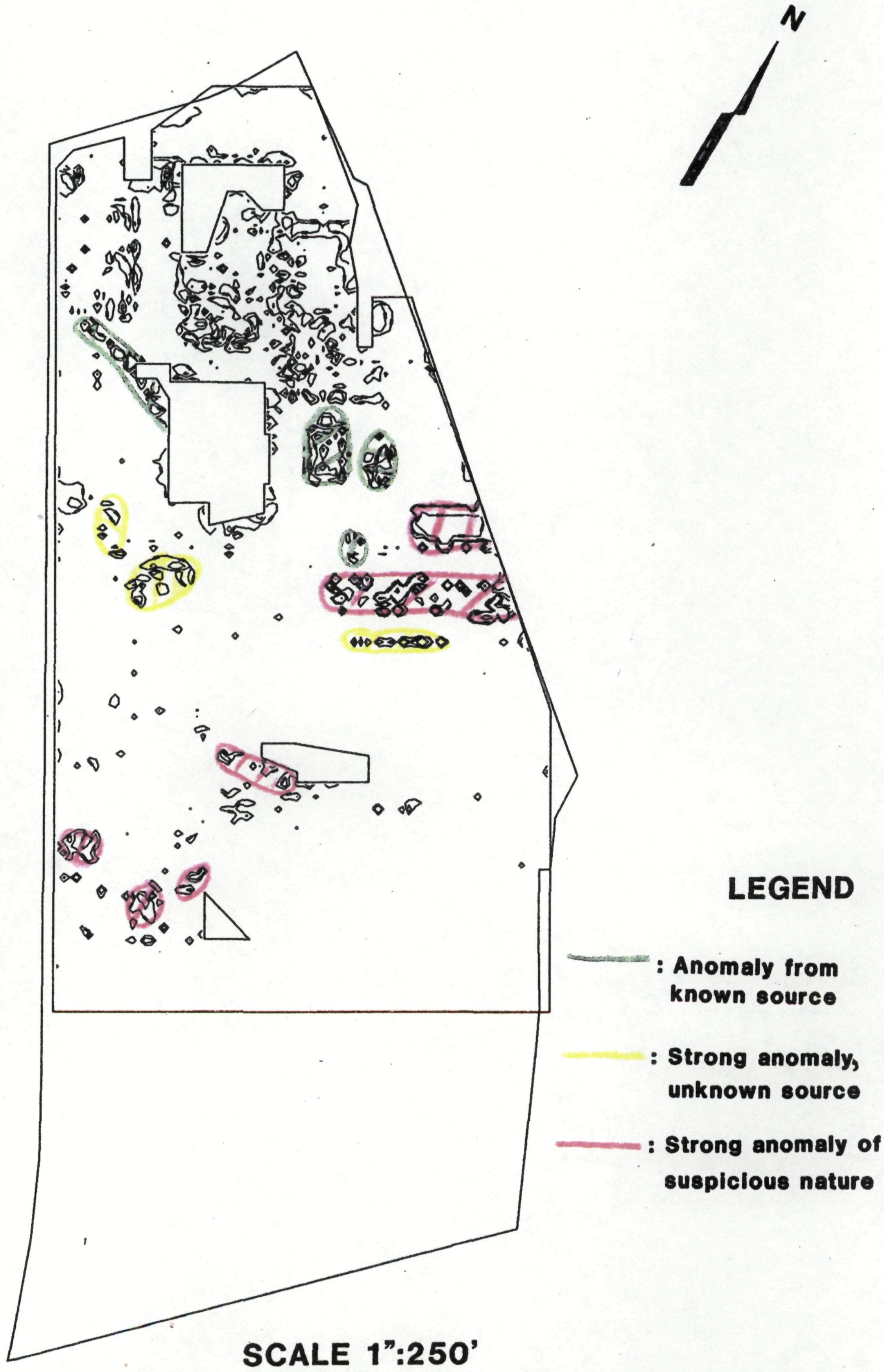
Figure 6:



SCALE 1":200'

MAGNETIC GRADIENT MAP - Unfiltered

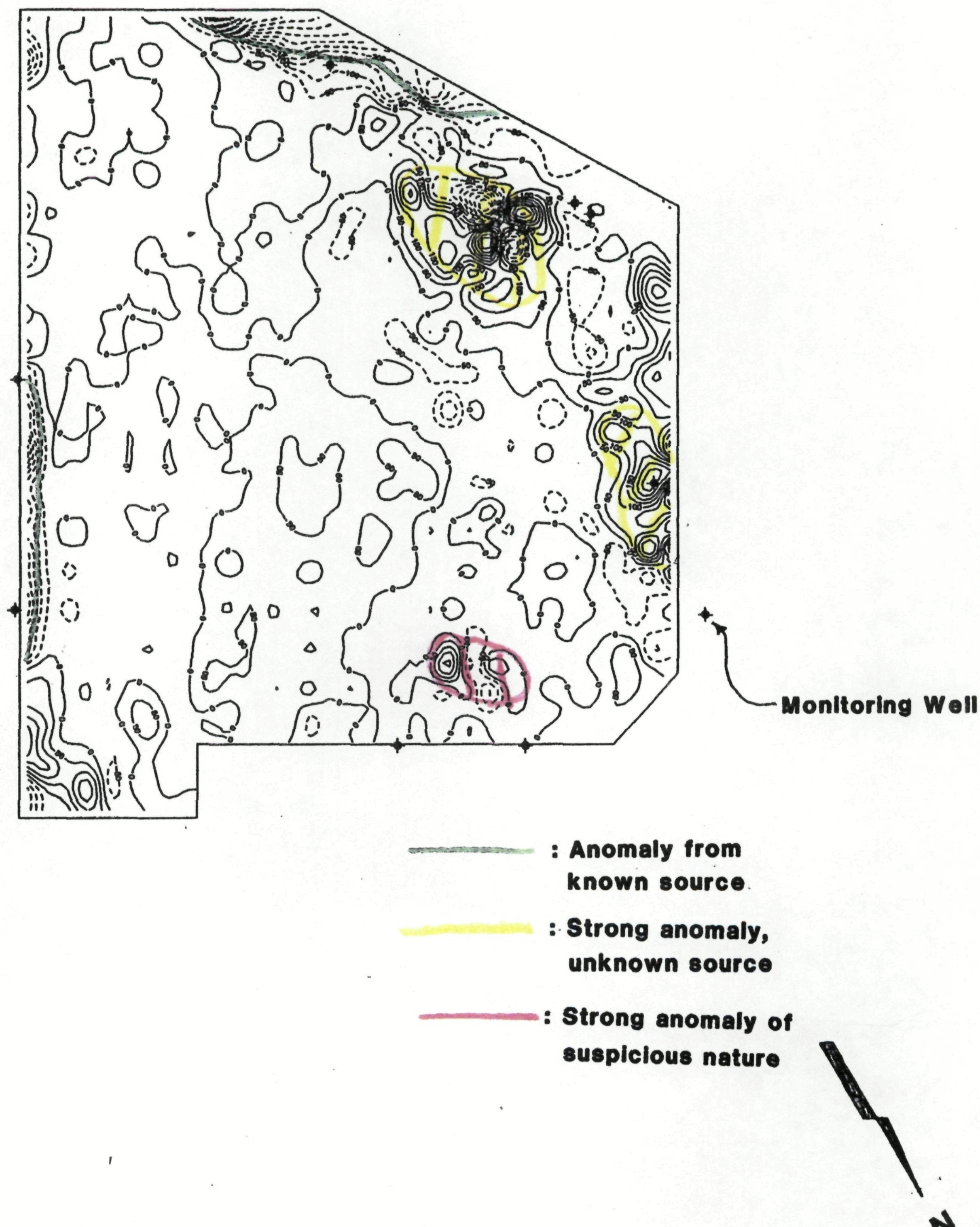
Figure 9:



MAGNETIC GRADIENT INTERPRETATION MAP

Figure 10:

INTERPRETATION



SCALE 1":100'

MAGNETIC GRADIENT MAP - LANDFILL

6.0 CLOSING

The field procedures and interpretative methodologies used in this project are consistent with standard, recognized practices in geophysical investigations. The correlation of geophysical anomalies with probable subsurface features is based on the past result of similar surveys although it is possible that some variation could exist at this site. This warranty is in lieu of all other warranties either implied of expressed. **LGI** assumes no responsibility for interpretations made by others based on work performed by or recommendations made by **LGI**.

C

APPENDIX C

LGI SOIL GAS SURVEY REPORT

A Division of Layne GeoSciences, Inc.

Project 44.2773

SOIL GAS SURVEY

at the

OLIN FACILITY

WILMINGTON, MASSACHUSETTS

FEBRUARY/MARCH 1992

Prepared for:

Conestoga-Rovers & Associates Limited
1801 Old Hwy. 8, Suite 114
St. Paul, Minnesota 55112

LGI

A Division of Layne GeoSciences, Inc.

6 Penn Highway • Sinking Spring, Pennsylvania 19608 • 215/670-5900 • 215/670-5903 (FAX)

April 8, 1992
Project #44.2773

Mr. Jon Michels
Conestoga-Rovers & Associates Limited
1801 Old Hwy. 8, Suite 114
St. Paul, Minnesota, 55112

Subject: *Soil Gas Survey at the Olin Facility in Wilmington, Massachusetts.*

Dear Jon:

LGI, a division of **Layne GeoSciences, Inc.**, is pleased to present the results of a soil gas survey of two (2) warehouse buildings at the **Olin** facility in Wilmington, Massachusetts. The survey was conducted in an attempt to delineate regions under the warehouses which may characterize buried drum waste.

1.0 SOIL GAS SURVEY - *Methodology*

1.1 Concept

Soil gas monitoring is a cost effective means of delineating the size and movement of organic contaminants in the subsurface. The objective in measuring organic gases in soil is to map the lateral extent of soil and groundwater contamination. A constant sampling depth is used to acquire soil gas readings across the study site. The values are then plotted on a map and contoured. The result is a contour plot of soil gas concentrations at a constant depth across the site. This plot should be linearly related to contaminant concentrations in groundwater or impacted substratum.

1.2 Technique

LGI conducted the soil gas survey utilizing a portable percussion hammer to install the soil boreholes throughout the study area. A 7/8" diameter case hardened steel drill bit and probe were advanced to the desired depth at each sample location. An air tight soil gas sampling port (**Figure 1**) was then installed. The sampling port consists of a section of one-half inch diameter PVC piping perforated and open at the bottom. The sampling end of the PVC piping consists of an air tight triple size-reducing tube assembly terminating in a ribbed double hose connector. A peristaltic pump was attached to the hose connector to generate a negative pressure in the sampling port and to purge the borehole. As designed, air can only be drawn into the sampling port from the base of the borehole, thereby eliminating near surface gases from entering the apparatus. An organic vapor analyzer (OVA) and an HNu were utilized at each sampling location to obtain soil gas readings (**Figure 2**). The OVA and HNu are field screening flame ionization and photo ionization detectors, respectively, which are used to measure the total concentrations of volatile organic compounds (VOCs).

The sample port installation equipment was decontaminated between each boring with a liquinox wash, followed by a tap water rinse, followed by a deionized water rinse. At the end of each day of sampling, the boring equipment was also rinsed with methanol before the tap and deionized water rinses.

2.0 WORK PLAN and DATA

LGI conducted a soil gas survey from February 5 through February 7, 1992. Fifteen (15) sample points (A series) were installed through the floor of the western warehouse, eighteen (18) sample points (B series) were installed through the floor of the eastern warehouse, ten (10) sample points (C series) were installed between the warehouse buildings, and seven (7) sample points (D series) were installed in the loading dock areas north of the buildings. **Figure 3** provides the locations of the A, B, C, and D series sample ports. To monitor potential off-gases escaping from the penetrated warehouse subsurfaces, an explosimeter was utilized during borehole installations.

All sample port borings were installed to a depth of three (3) feet. The concrete floors inside the warehouses were approximately one (1) foot thick. Refusal was encountered at sample port location B19, at a depth of six (6) inches. The OVA and HNu readings are summarized in **Table 1** and illustrated on **Figures 4** through **6**.

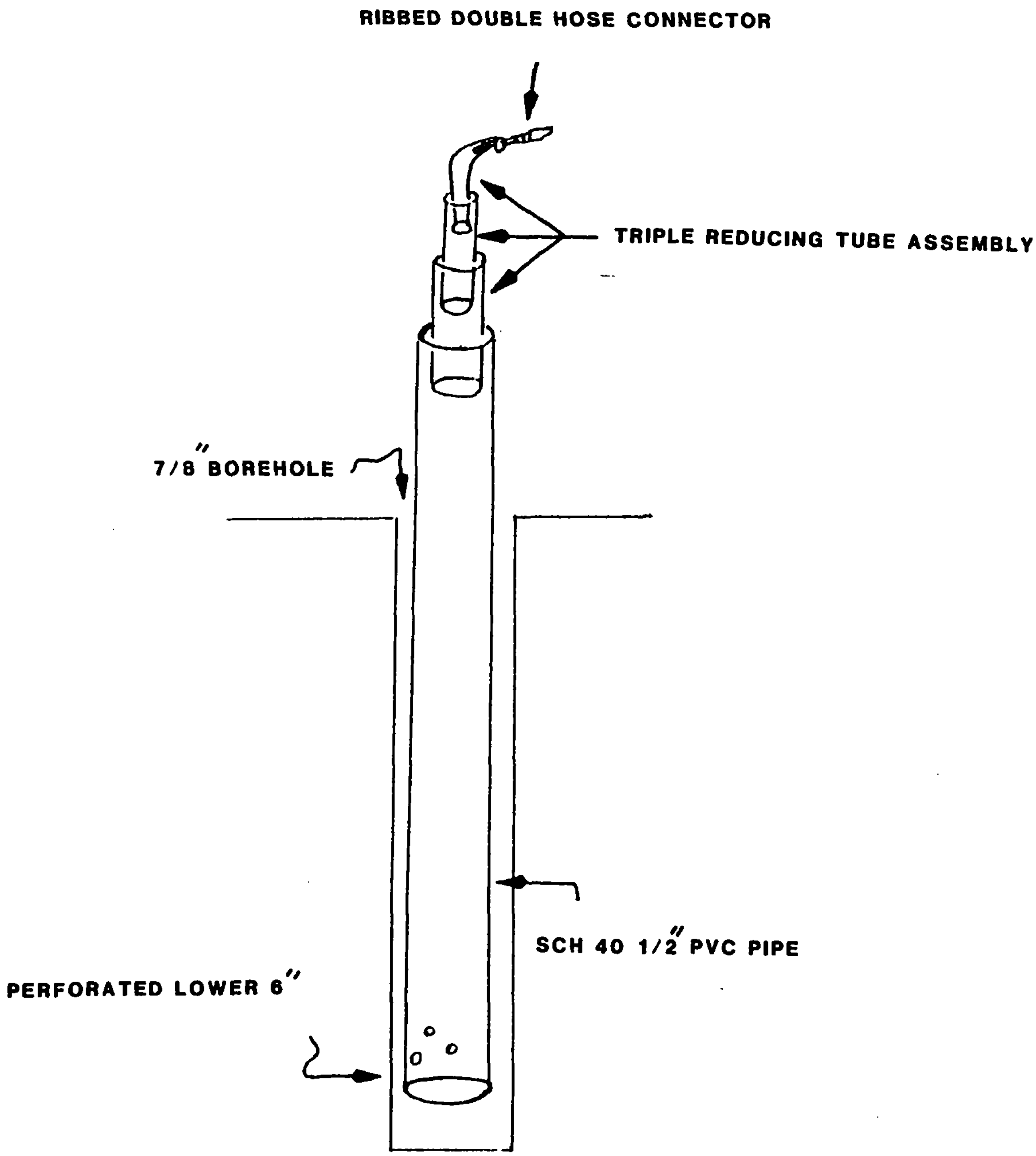


FIGURE 1 : Soil Gas Sampling Port

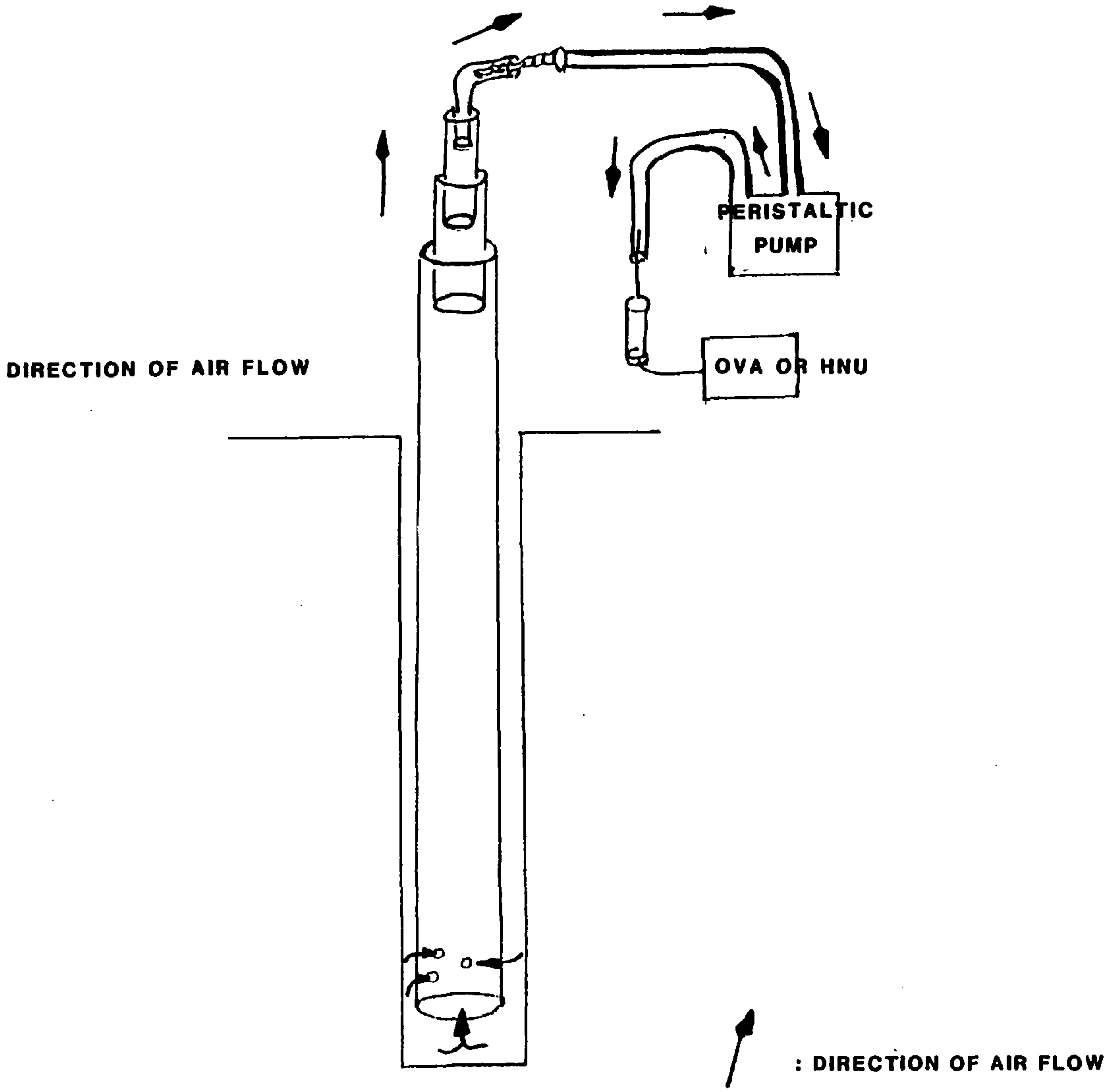


FIGURE 2 : Soil Gas Sampling System

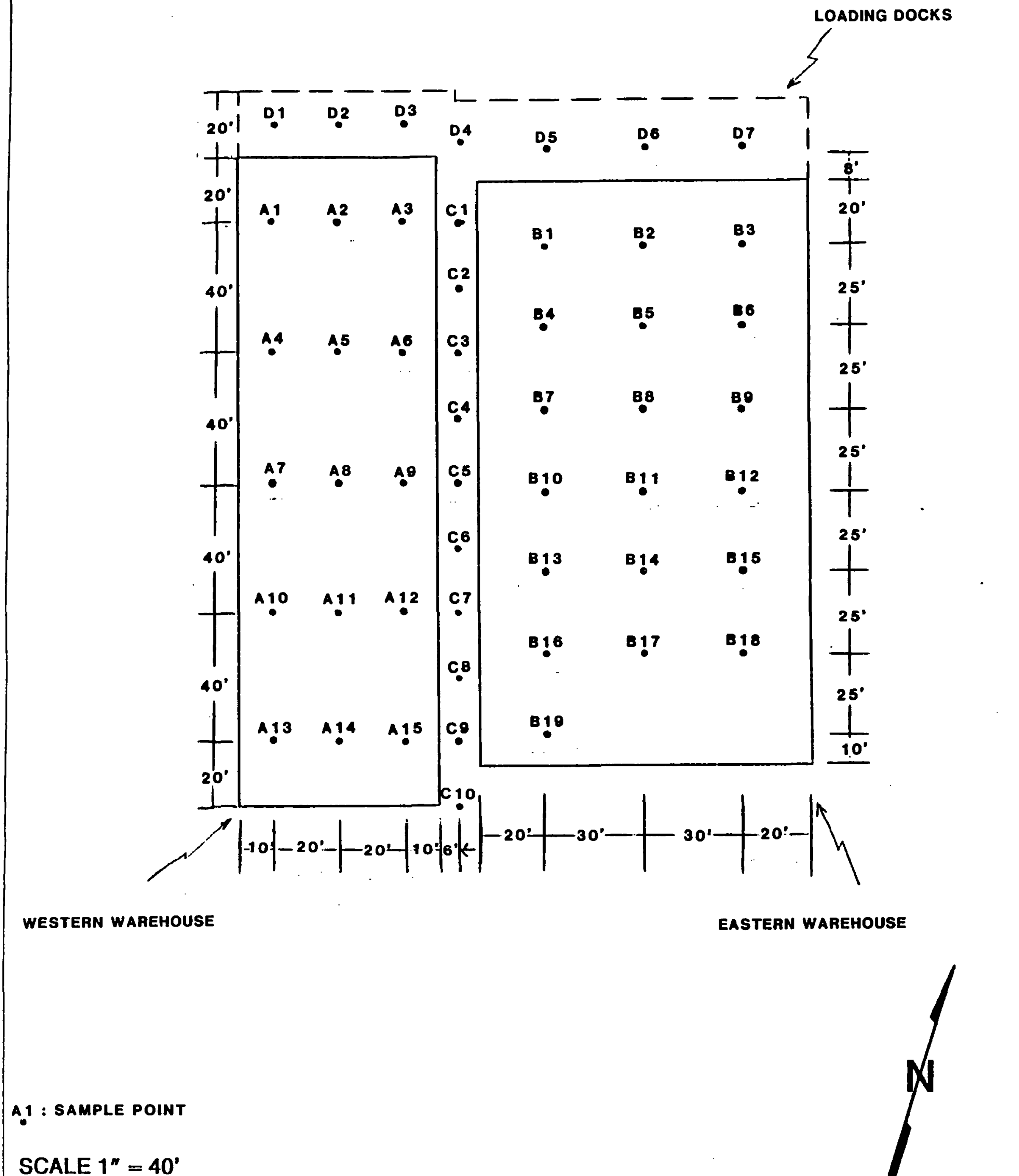


FIGURE 3: SAMPLE LOCATIONS

TABLE 1

Summary of Soil Gas Survey Results

Location	OVA Peak	OVA Stabilized	HNu Reading
A1	5.0	3.0	0.0
A2	4.5	3.5	0.0
A3	10.0	10.0	2.0
A4	10.0	9.5	2.0
A5	6.0	5.5	1.5
A6	65.0	50.0	1.0
A8	0.5	0.5	0.0
A7	0.0	0.0	0.0
A9	5.0	4.5	1.0
A10	1.5	1.0	0.0
A11	0.0	0.0	0.0
A12	0.5	0.5	0.0
A13	0.5	0.0	0.0
A14	1.0	1.0	0.0
A15	0.0	0.0	0.0
B1	0.0	0.0	0.0
B2	8.0	6.5	0.5
B3	4.0	3.5	0.0
B4	3.5	3.0	1.0
B5	4.5	3.5	0.0
B6	9.5	4.0	0.0
B7	4.0	4.0	2.0
B8	5.0	4.0	2.0
B9	10.0	4.5	1.5
B10	5.5	3.0	1.0
B11	3.0	2.0	1.5
B12	10.0	5.0	1.5
B13	3.5	3.0	0.5
B14	3.0	3.0	0.5
B15	3.0	2.5	0.0
B16	25.0	6.0	2.5
B17	7.5	4.5	1.0
B18	7.0	4.0	1.0
B19	R	R	R
C1	6.0	5.0	0.5
C2	100.0	100.0	50.0
C3	300.0	300.0	80.0
C4	1.0	1.0	2.0
C5	5.0	5.0	1.0
C6	10.0	8.0	4.5
C7	55.0	55.0	30.0
C8	10.0	9.0	4.0
C9	10.0	9.5	5.0
C10	4.5	4.0	2.0
D1	7.0	4.5	1.0
D2	0.5	0.5	1.0
D3	11.0	5.5	1.0
D4	6.0	4.5	1.0
D5	6.5	5.0	1.5
D6	0.5	0.5	0.5
D7	2.0	1.5	1.5

R = borehole refusal.
OVA and HNu readings are in parts per million.

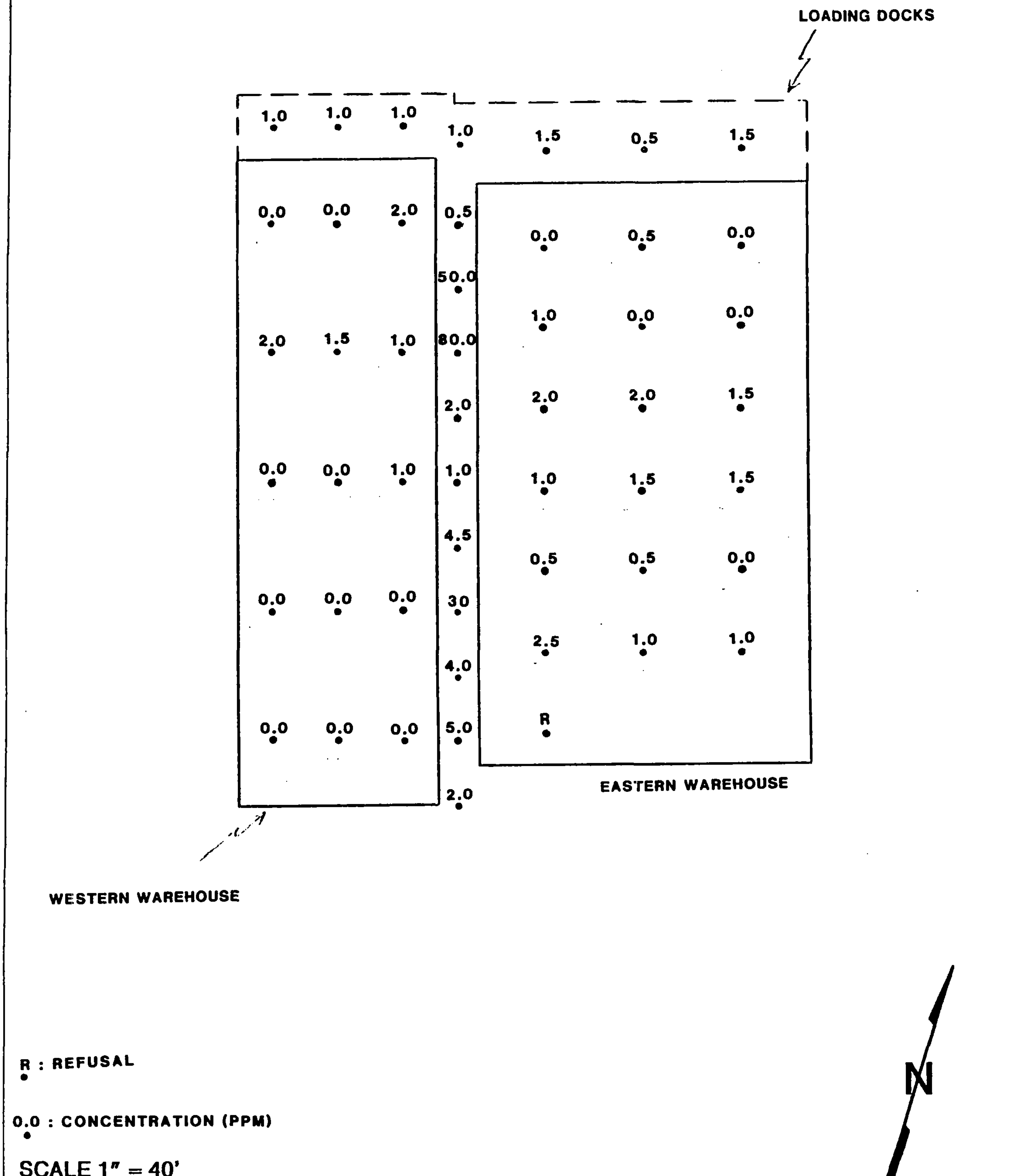


FIGURE 4: HNu READINGS

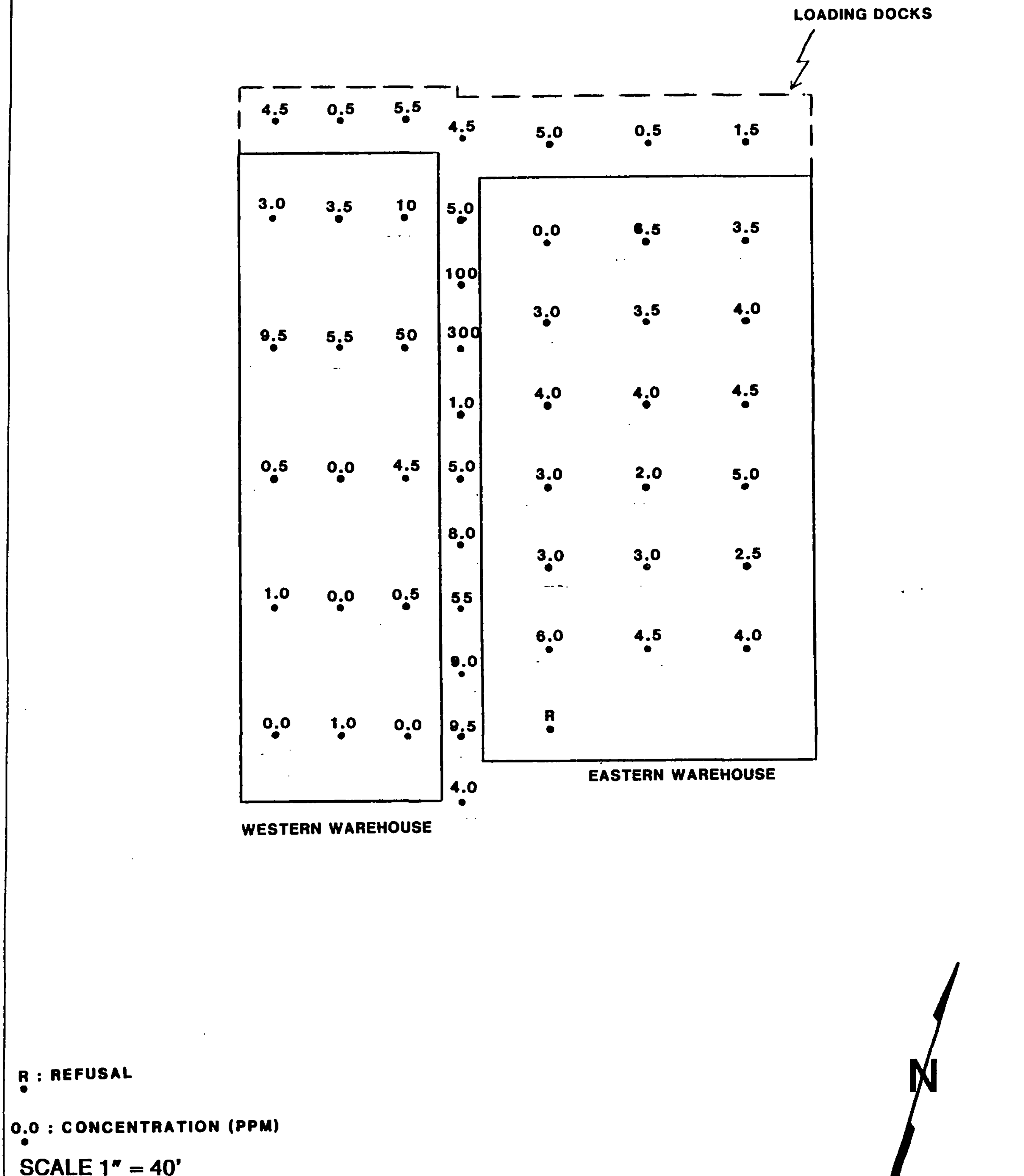


FIGURE 5: OVA STABLE READINGS

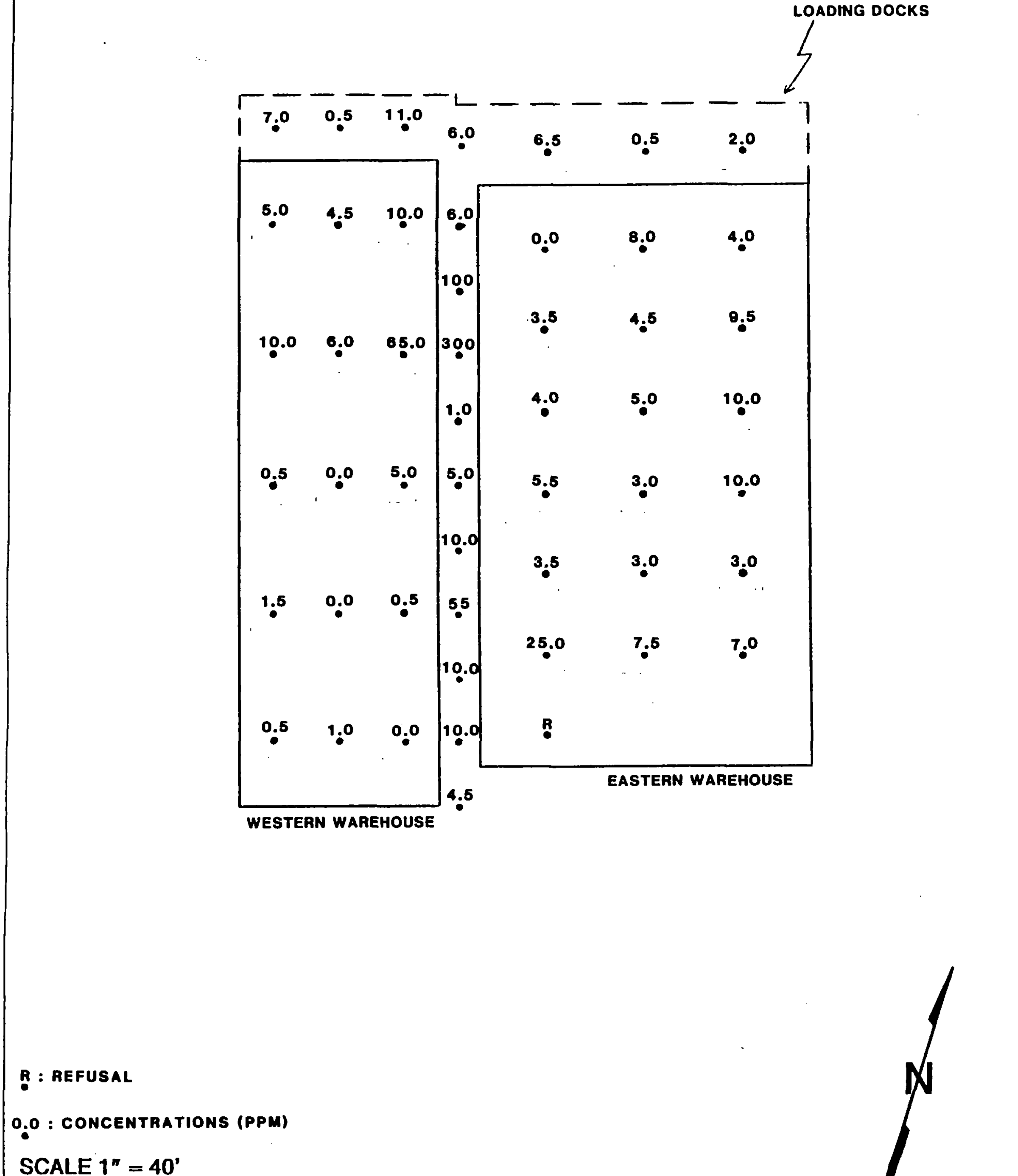


FIGURE 6: OVA PEAK READINGS

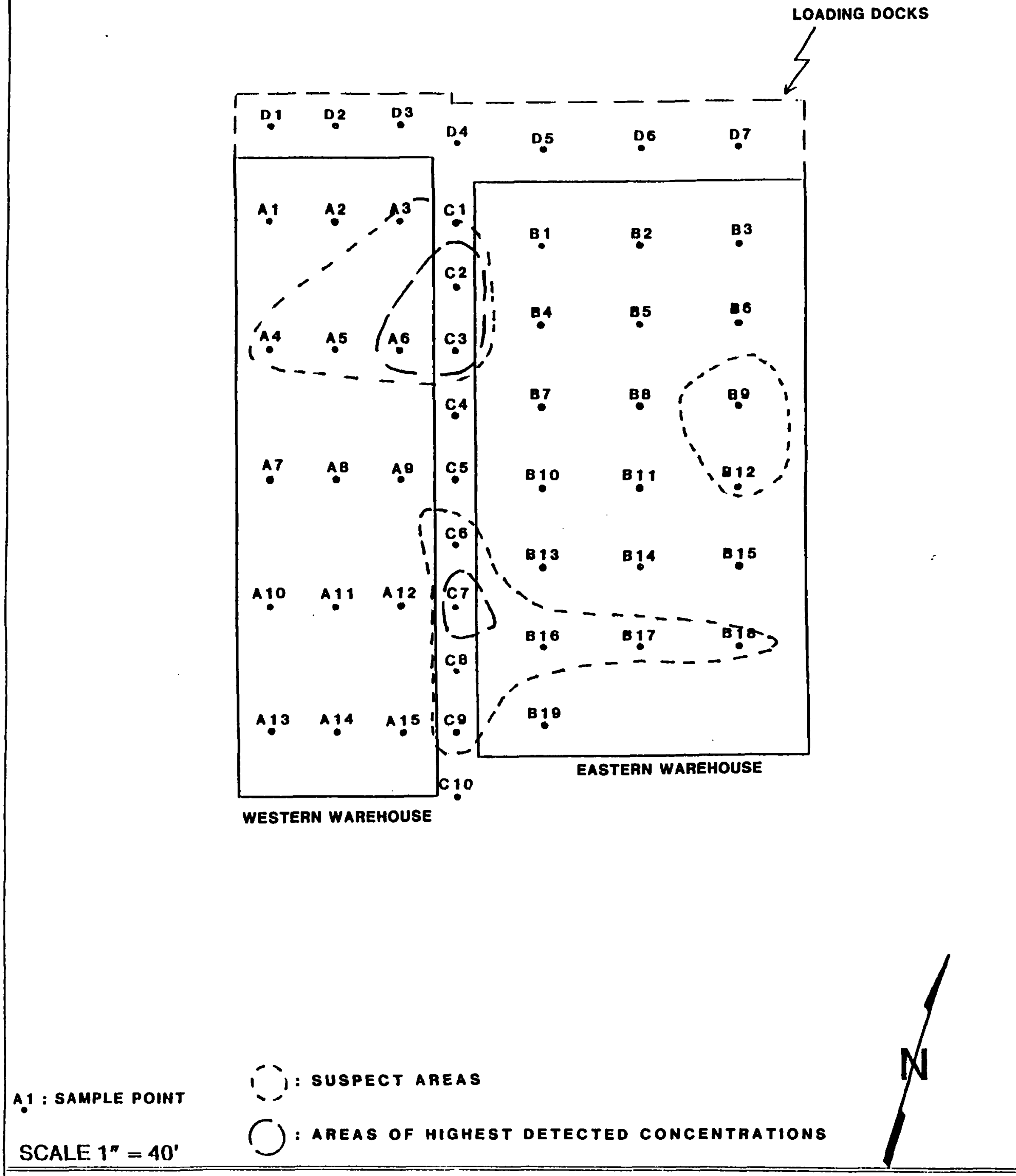


FIGURE 7: Suspect Areas

The OVA peak reading is the initial response to the soil gas, which presents the highest contaminant concentration. The peak OVA reading is obtained immediately after borehole installation. The stabilized reading represents the "steady" soil gas concentration after the release of any built-up gases from the subsurface.

3.0 CONCLUSIONS

The range of VOC concentration values for the OVA - peak, OVA - stabilized, and the HNu, were 0 to 300, 0 to 300, and 0 to 80 ppm, respectively. Correspondingly, the means were 15.21, 13.47, and 4.21 ppm. Ten percent (5 entries) of the OVA - peak and HNu readings were above their respective means. Eight percent (4 entries) of the OVA - stabilized readings were above the mean. Three above mean sample port locations were common to all three sets of results, namely C2, C3, and C7. A6 was above the mean for both sets of OVA results. These locations have been labelled as "areas of highest detected concentrations" on **Figure 7**. Secondary suspect areas have also been outlined according to relative detected VOC concentrations.

LGI recommends investigating the three (3) suspect areas outlined in **Figure 7** by utilizing a combination of ground penetrating radar (GPR) and backhoe excavations. These areas should be surveyed with GPR, followed by the excavation of the areas located between the warehouse buildings via a small backhoe or skid loader.

If you have any questions concerning this project, or the conclusions presented in this report, please do not hesitate to call.

Sincerely,
LGI, a division of **Layne GeoSciences, Inc.**
Environmental and Groundwater Scientists

Michael P. Raffoni
Project Manager

D

APPENDIX D

LGI SEISMIC REFRACTION SURVEY REPORTS

A Division of Layne GeoSciences, Inc.

Project #44.2722

SEISMIC INVESTIGATION

near the

OLIN CHEMICAL FACILITY
WILMINGTON, MASSACHUSETTS

Prepared for:

CONESTOGA-ROVERS AND ASSOCIATES
1801 OLD HIGHWAY 8, SUITE 114
ST. PAUL, MN 55112

FEBRUARY - APRIL 1992

Integrated Solutions to Complex Problems

Project #44.2722

SEISMIC INVESTIGATION

near the

OLIN CHEMICAL FACILITY
WILMINGTON, MASSACHUSETTS

Prepared for:

CONESTOGA-ROVERS AND ASSOCIATES
1801 OLD HIGHWAY 8, SUITE 114
ST. PAUL, MN 55112

FEBRUARY - APRIL 1992

1.0 OVERVIEW

During February, 1992, **LGI, a division of Layne GeoSciences, Inc.**, conducted a seismic refraction investigation within the swamp area west of the Olin Chemical facility, Wilmington, Massachusetts (see **Figure 1**). The purpose of the geophysical investigation was to delineate bedrock topography in an area approximately 3500 feet west of a previous study undertaken by **LGI** (October, 1991). The existence of a buried, bedrock channel is suggested from the previous report submitted by **LGI** to **Conestoga-Rovers & Associates** (**CRA**). Four cross-sectional traverses totaling 4540 linear feet and three individual seismic refraction profiles were collected during the February, 1992, seismic investigation. Seismic data interpretation revealed that the bedrock morphology is channelized and appears to deepen to the northwest.

2.0 THEORY AND FIELD DESIGN

2.1 Theory

SEISMIC REFRACTION

The seismic refraction method involves measuring the direct path taken by sound waves as they propagate within the subsurface away from the seismic source. Ground movement is detected by the geophones and recorded on the seismograph for subsequent interpretation. From these responses, compressional-wave velocities are calculated and the depth to subsurface interfaces is determined.

Sound waves travel at different rates through dissimilar materials (i.e., greater sound velocities attained through more solid, denser media). Insight on the relative hardness of subsurface materials can be predicted from the seismic method and this is necessary in order to provide information concerning subsurface depths and contrasts in lithology.

SEISMIC REFLECTION

The seismic reflection method involves measuring sound energy as it reflects off subsurface interfaces and returns to the surface. Seismic reflections are generally observed along seismic lines within a narrow "window". A seismic reflection window consists of those geophone locations which fall within the area where primary seismic reflections can be best recorded. A seismic window (if present) generally falls approximately twice the bedrock depth away from the energy source. By utilizing overburden velocities determined from seismic refraction data, the depth to bedrock within the reflection window is resolved.

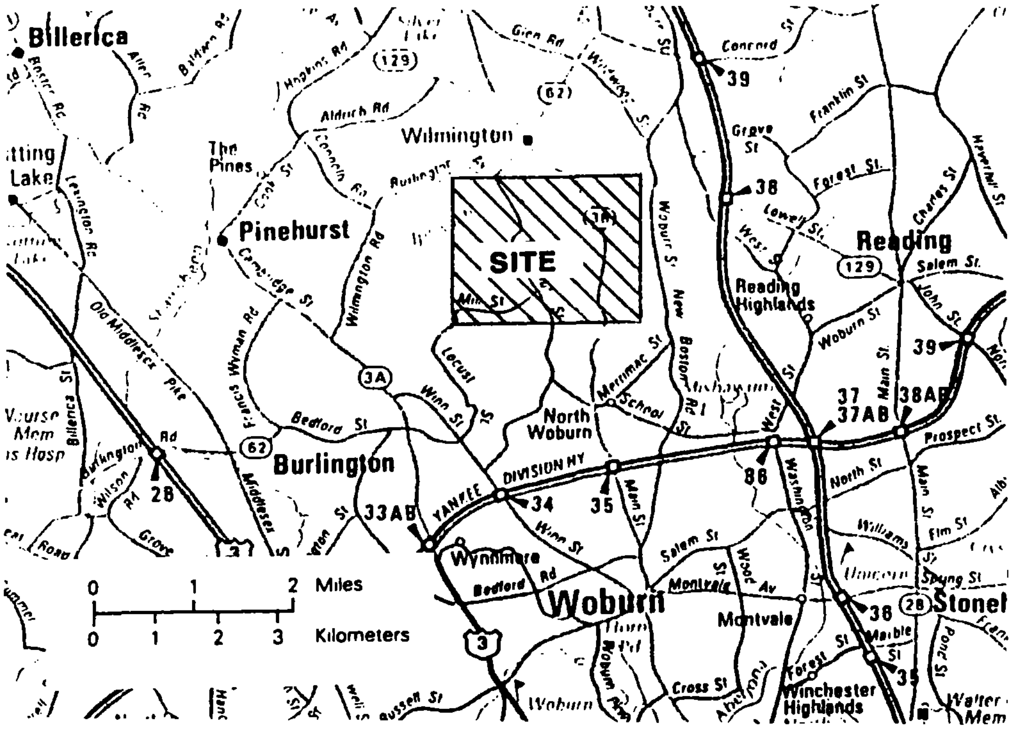
2.2 Instrumentation

LGI conducted the seismic study with similar parameters and instrumentation used during the October, 1991, survey. All seismic lines consisted of twenty-four (24) sound receivers (geophones) spaced at ten foot intervals. The seismic source consisted of a black powder packed 10 gauge shot. Seismic data was recorded on a 24-channel seismograph. Downloading of the field records to a computer was performed for subsequent data reduction and interpretation.

2.3 Field Design

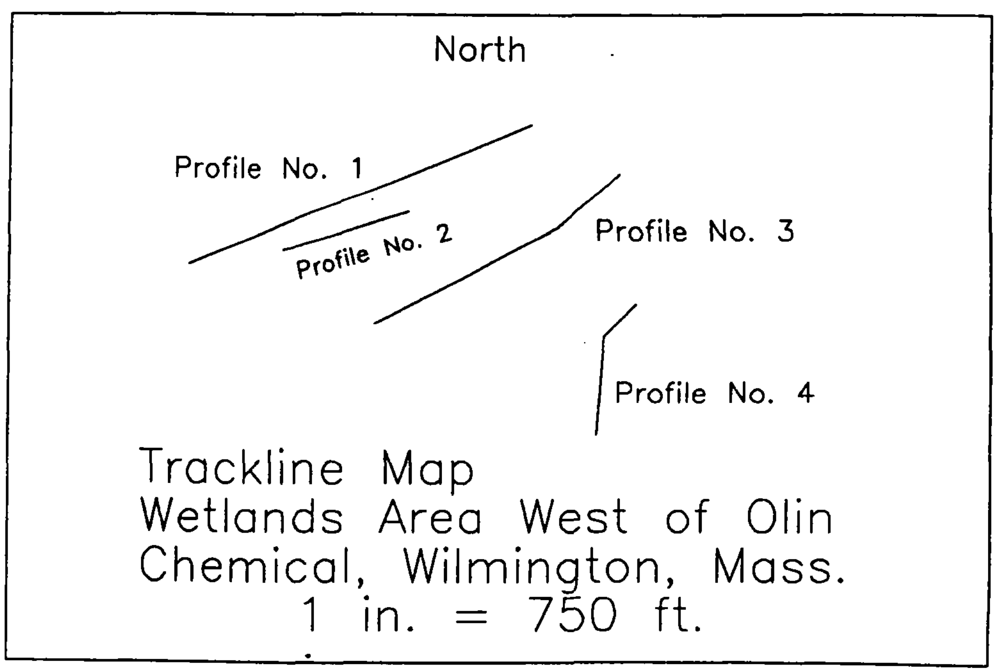
Twenty-one seismic lines were acquired within the study area. Three of these lines (10 - 12) were collected in an industrial area east of the Olin site. A seismic source offset (ranging from 20-80 feet) was used to profile subsurface interfaces within 100 feet of the surface. The four seismic traverses were oriented nearly parallel to one another in a southwest-northeast direction (see **Figure 2**). *The profile numbering system used in this report is based on lateral position and is not the order in which the traverses were collected.* Adjacent seismic lines were overlapped between 20 and 40 feet to provide more complete bedrock coverage. All shotpoint locations were labeled and flagged for subsequent surveying.

FIGURE 1:



SITE LOCATION MAP

FIGURE 2:



PROFILE LOCATION MAP

3.0 RESULTS

3.1 Data Interpretation

Bedrock depths were resolved utilizing standard seismic refraction and reflection software. Upon close examination of the seismic data, the presence of bedrock reflections was noticed. Although survey parameters were not specifically designed to detect seismic reflections, the geologic conditions and survey parameters resulted in high quality bedrock reflections along several seismic lines. In many cases, the swamp conditions and poor weather conditions dampened seismic refraction arrivals, although reflections were present.

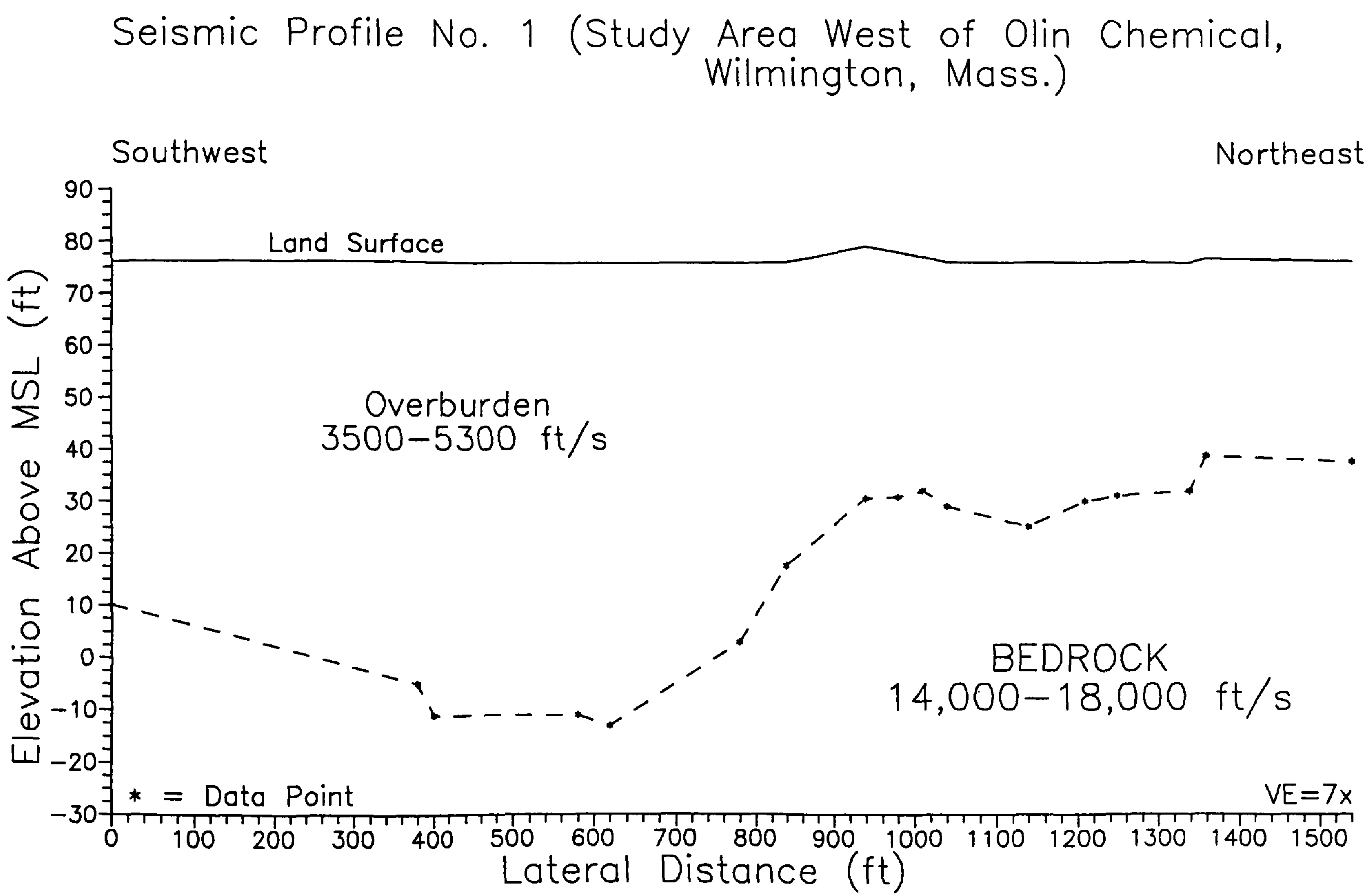
Seismic data interpretation coupled with a velocity analysis yielded two distinct geologic layers for the cross-sectional profiles generated in this report. Overburden velocities ranged from 3400-6000 ft/s (unconsolidated, water-saturated, sediments) and crystalline bedrock velocities were calculated to range from 13,000-18,000 ft/s.

The depth to bedrock information determined from the seismic data was combined with surface elevation data (provided by **CRA**) to generate cross-sectional profiles (see **Figures 3 - 6**). The profiles are a two-dimensional representation of the overburden/bedrock interface below the land surface along each traverse. Irregular features displayed on the bedrock surface are due to the nature of the interpretive software and are not as abrupt in actuality. Except where noted, seismic refraction data interpretations were used as final depth determinations.

3.2 Profile No. 1

Seismic Profile No. 1 was the northernmost traverse acquired within the study area (see **Figure 3**). Depths to bedrock range from at least 38 feet to a maximum of 95 feet. The bedrock surface appears channelized along the southwestern portion of this traverse. Seismic data quality for Profile No. 1 was good and the velocity values calculated appear to match the described lithologies for this area. Seismic reflection data interpretations were used for shot records 1F, 2F, 2R, 3F, 3R, 4F, 4R2 & 7F.

FIGURE 3:



Seismic Profile No. 1 (Study Area West of Olin Chemical, Wilmington, Mass.)
Southwest
Northeast
Land Surface
Overburden
3500–5300 ft/s
BEDROCK
14,000–18,000 ft/s
* = Data Point
VE=7x
Elevation Above MSL (ft)
Lateral Distance (ft)
90
80
70
60
50
40
30
20
10
0
−10
−20
−30
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500

FIGURE 4:

Seismic Profile No. 2 (Wetlands Area West of Olin Chemical, Wilmington, Mass.)

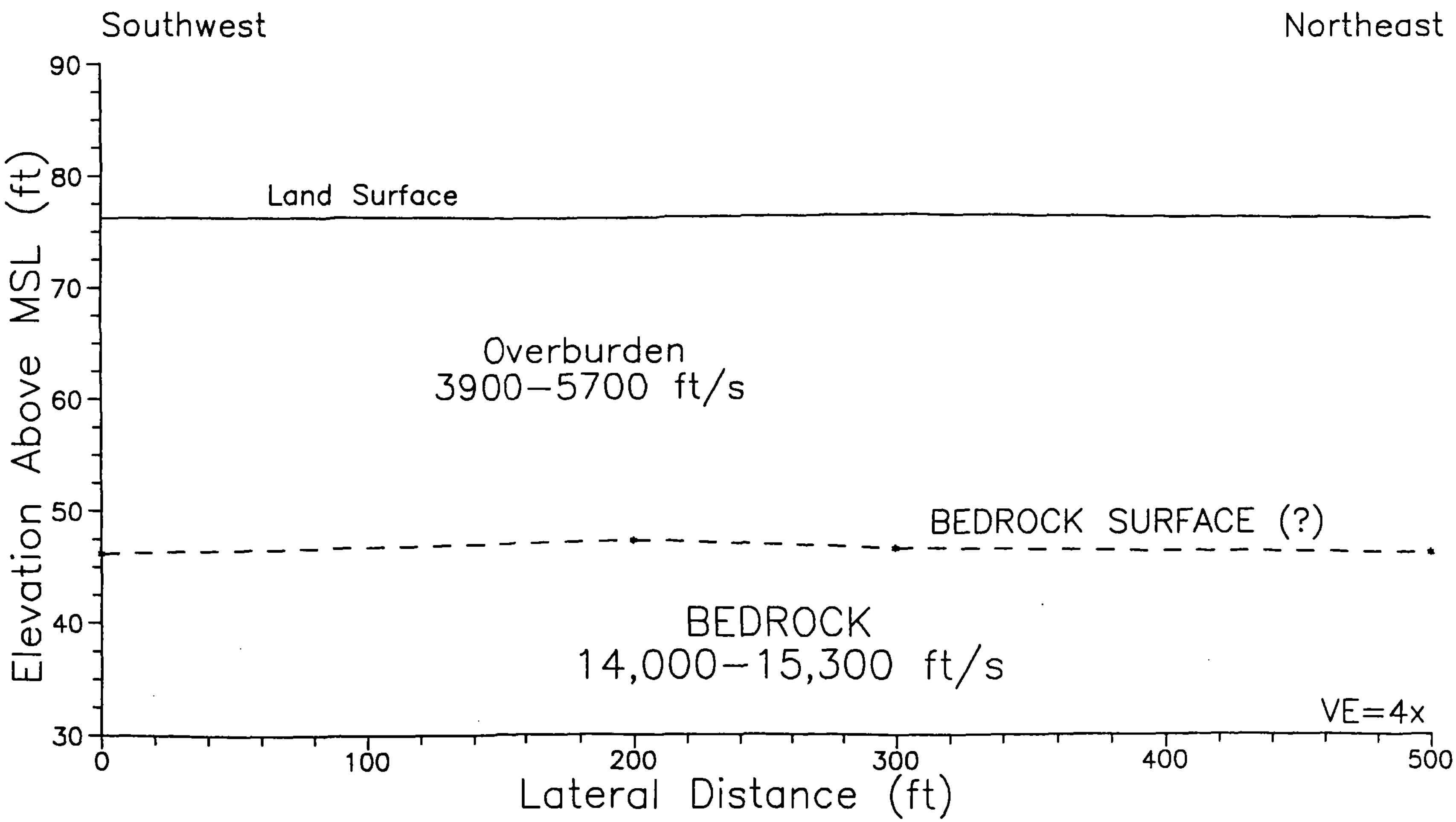


FIGURE 5:

REVISED

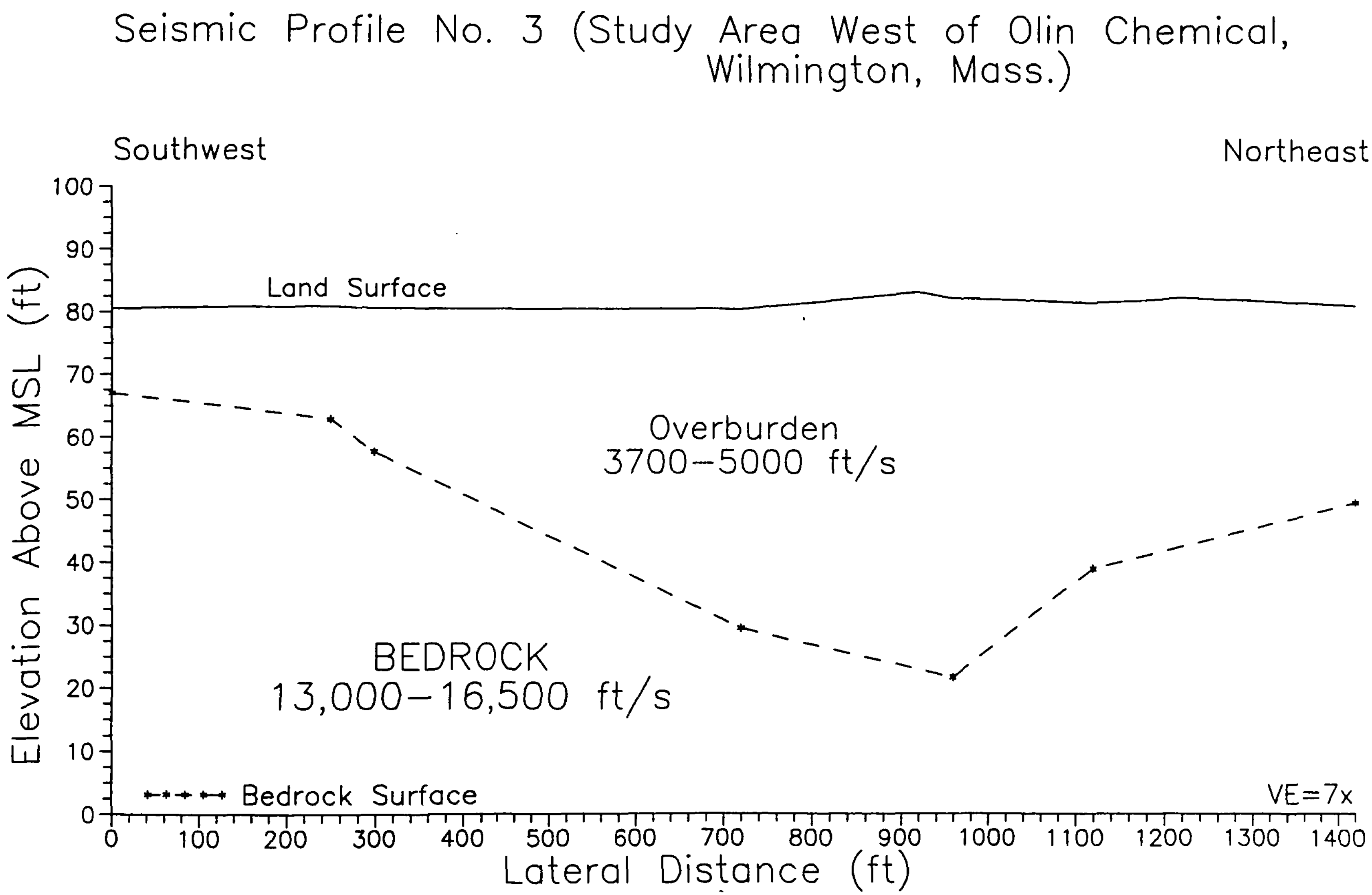
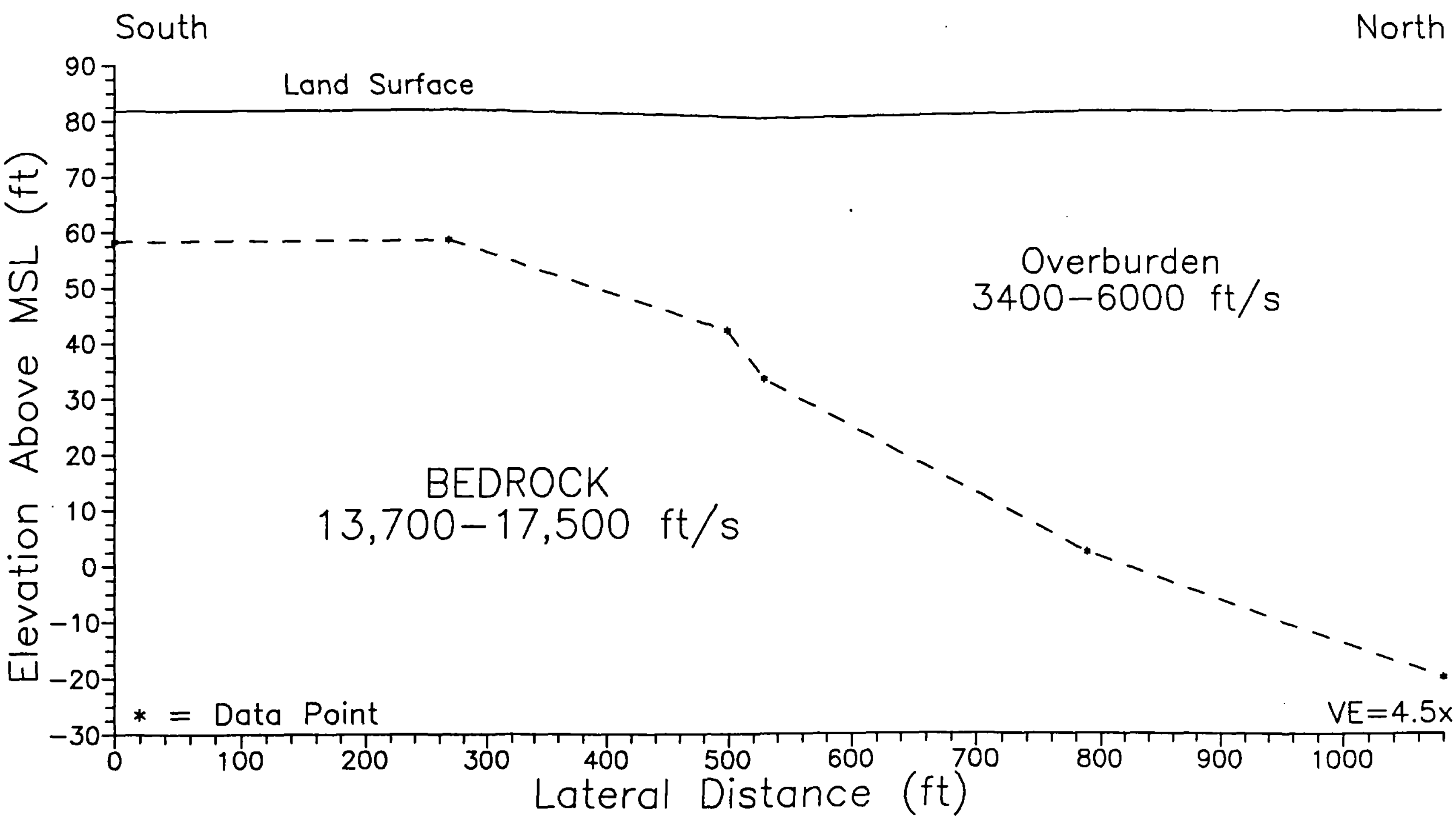


FIGURE 6:

Seismic Profile No. 4 (Study Area West of Olin Chemical, Wilmington, Mass.)



3.3 Profile No. 2

A second seismic profile was positioned approximately 150 feet southeast of Profile No. 1 (see **Figure 4**). Data quality was poor along this traverse due to windy weather conditions. Interpretation is suspect for Profile No. 2. Velocity values appear consistent with the other profiles, but the depths to bedrock and morphology do not agree with the other traverses. The bedrock surface along Profile No. 2 appears flat-floored with a minimum of 30 feet of sediment overlying bedrock. Seismic reflection data interpretations were used for shot record 21R.

3.4 Profile No. 3

A channel-like feature on the bedrock surface was interpreted along Profile No. 3 (see **Figure 5**). This traverse is located approximately 600 feet southeast of Profile No. 1. Data quality of Profile No. 3 is fair, but some of field records were noisy making interpretation of the seismic data difficult. Velocity ranges for this profile appear reasonable for the overburden and bedrock. Bedrock appears to deepen towards the central portion of the traverse and maximum depth to bedrock is reported at 61 feet. Along the southwestern margin of the profile bedrock appears to shallow to a depth of 14 feet. Seismic reflection data interpretations were used for shot records 9F, 9R, 13F & 13R.

3.5 Profile No. 4

Profile No. 4 was acquired approximately 1200 feet southeast of Profile No. 1 (see **Figure 6**). Bedrock appears channelized in cross-section with a maximum depth of 102 feet projected to bedrock near the north edge of the profile. Data quality was generally poor due to weather conditions. Only six data points were plotted for the bedrock surface profile because of poor data quality. Reasonable velocity values were generated from interpretable data providing confidence in the interpretation of Profile No. 4. Seismic reflection data interpretations were used for shot records 19F & 19R.

3.6 Profiles East of Olin Site

Three separate seismic lines were collected east of the Olin facility along Woburn Avenue and Presidential Road. The bedrock surface below seismic lines 10, 11, & 12 ranged from thirty to forty-five feet. Overburden velocities ranged between 2600 - 4000 ft/s. Bedrock velocities ranged between 9000 and 16400 ft/s. Industrial machinery in surrounding buildings contributed substantial seismic noise. Surface elevations were not known; a value of 100 feet was used for all surface elevations when constructing the bedrock profiles. Bedrock profiles for these seismic lines are included in Appendix A.

4.0 ASSESSMENT

The results of this investigation were compared with those from the October 1991 seismic refraction survey. As stated previously, the buried bedrock valley appears to deepen to the northwest. Although the traverses are laterally separated, certain comparisons can be made. The survey in October 1991 encountered varying degrees of cultural seismic noise (noise) in all areas of the site. The effects on the seismic velocity analysis were not fully known until certain seismic lines (4R, 5F, 5R2 & 6F) from the February 1992 survey were interpreted. These lines displayed virtually no external seismic interference, allowing both overburden and bedrock velocities to be calculated with high confidence. The bedrock velocities under these seismic lines were found to be much higher than most velocities resolved from the October 1991 survey, while the overburden velocities in the swamp are consistent with saturated porous sediment velocities.

When entered into the equation used to determine depth from seismic refraction data, a higher bedrock velocity will resolve the bedrock surface at a deeper depth, provided all other factors are constant. The presence of seismic noise during the October 1991 survey may have masked true refraction arrivals and resulted in slower bedrock velocities. This is possible since ground truths, determined from drilling since the October 1991 survey, reveal that the bedrock surface is actually deeper in many places than the seismic refraction interpretations resolved.

5.0 CLOSING

The field procedures and interpretive methodologies used in this project are consistent with standard, recognized practices in geophysical surveying. This warranty is in lieu of all warranties either implied or expressed. **LGI** assumes no responsibility for interpretations made by others based on work performed by or recommendations made by **LGI**.

APPENDIX A

INDIVIDUAL PROFILES EAST OF OLIN SITE

Mic helo

A Division of Layne GeoSciences, Inc.

PROJECT #44.2628

GEOPHYSICAL INVESTIGATION

AT THE

OLIN CHEMICAL FACILITY
WILMINGTON, MASSACHUSETTS

PREPARED FOR:

CONESTOGA - ROVERS
382 WEST COUNTY ROAD D
ST. PAUL, MN 55112

NOVEMBER 1991

Integrated Solutions to Complex Problems

1.0 OVERVIEW

On October 7th-10th, 12th-14th, 1991, **LGI**, a division of **Layne GeoSciences, Inc.**, performed a seismic refraction investigation near the Olin Chemical facility in Wilmington, Massachusetts (see **Site Location Map**). The purpose of the investigation was to profile the bedrock surface to determine the existence and extent of a possible bedrock valley near the Olin facility. The proposed traverses were located in an industrial area. As a result, a significant amount of cultural seismic noise (traffic, compressors, equipment, etc.) was anticipated.

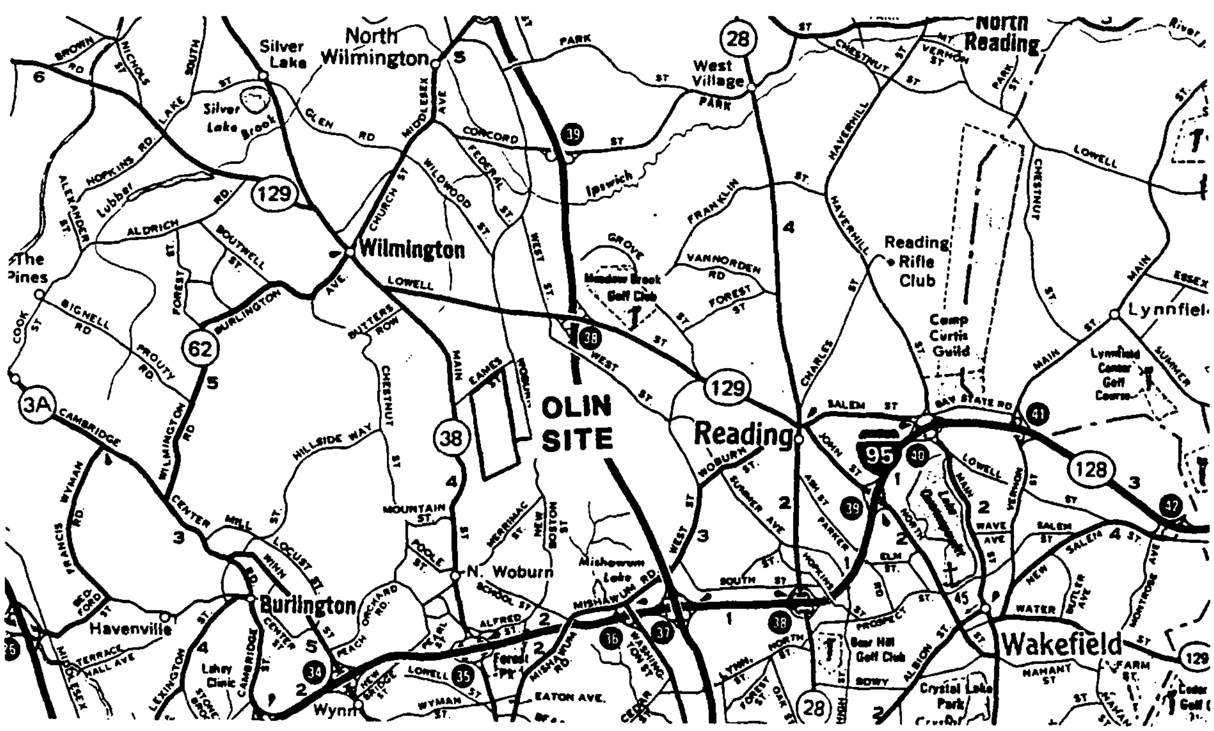


FIGURE 1: Site Location Map

2.0 METHODOLOGY AND FIELD DESIGN

2.1 Theory and Instrumentation

The seismic method involves the transmission of sound waves into the earth, and recording the earth's resulting response at set distances from the seismic energy "source"; this process constitutes one "seismic line". Each seismic line consists of twenty-four (24) receivers (geophones) which record the seismic energy (see **Figure 2**).

The seismic data is reduced and interpreted yielding a two-dimensional model of the subsurface. One two-dimensional model is derived from each seismic line. Because sound waves travel at different rates through dissimilar materials (i.e., faster through harder and denser materials), an insight to the relative hardness of subsurface materials can be discerned. Consequently, the seismic method furnishes information concerning the depth and relative strength or nature of subsurface materials.

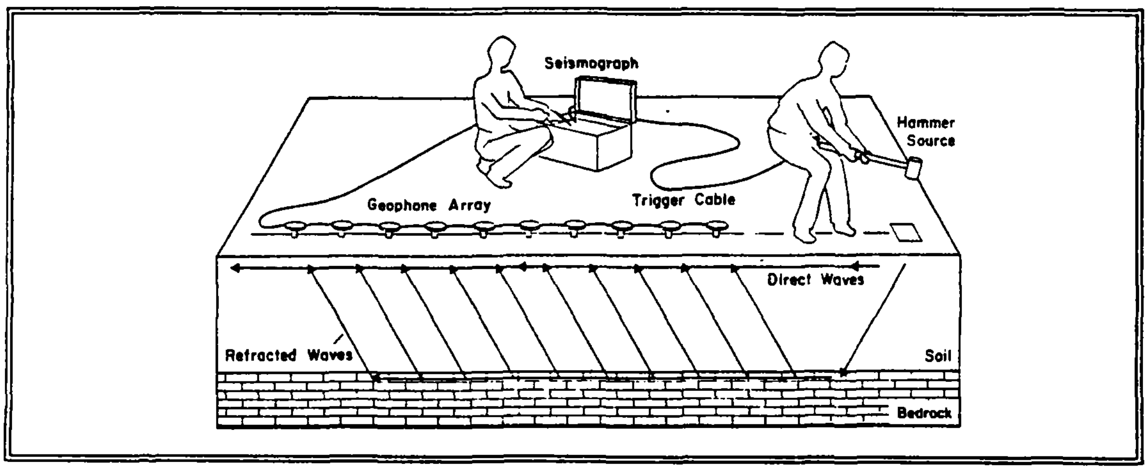


Figure 2: Generalized seismic line diagram.

2.2 Seismic Field Design

Approximately 1150 depth points were generated via the seismic refraction method by locating 48 seismic data acquisition lines (seismic lines) over the site. To ensure a depth of exploration of at least 70 feet, most seismic lines were designed with a ten foot geophone (receiver) spacing and a ten foot source offset. In addition, five seismic lines (32, 33, 43, 44 & 48) were collected utilizing five foot geophone spacings and offsets to better resolve contrasts in areas of shallower bedrock.

Seismic lines were located along five primary traverses: Eames St., Jewel Dr., Route 38 North & South, and along the railroad tracks west of the Olin site. In most cases, seismic lines were overlapped twenty feet to provide more complete bedrock coverage. In addition several other individual lines were distributed throughout the area to provide bedrock information in the region. Seismic lines were placed primarily on the street and railroad right-of-ways. Seismic lines which were not a part of the traverses were placed in relatively open and accessible areas. See **Figure 3** for approximate seismic line locations.

3.0 INTERPRETATION

As expected, the seismic data analysis yielded a complex bedrock surface. The depth to bedrock information determined from the seismic refraction has been combined with surface elevation data (provided by CRA) to produce seismic cross-sections below each traverse and each isolated seismic line. As revealed by the **Bedrock Profiles** (Appendix A), the depth to bedrock ranges from under six feet (6') to over forty feet (40') below the existing land surface. As a result of the seismic line geometry utilized for the investigation, the bedrock depth accuracy is +/- five feet (5'). Cultural noise presented many difficulties during the field and interpretative phases of the investigation. Several cultural interferences (traffic, compressors, etc.) produce vibrations which are within the frequency range of the refracted seismic data. As a result, refracted waveforms can become distorted. to increase the signal-to-noise ratio during data collection, 10 gauge shotgun shells were utilized as a source. Multiple shots were also collected at several locations. Final seismic line interpretations were completed after referencing adjoining lines (along the same traverse) to ensure consistent transitions.

The **Bedrock Profiles** represent the bedrock surface directly below the existing grade along each traverse. The sharp features displayed on the bedrock profiles are due to the nature of the interpretative software and are not as abrupt in actuality. All mapped bedrock is considered competent; however, there may be pockets of rippable, decomposed rock scattered throughout the site.

The seismic refraction investigation revealed the presence of a valley feature extending to the west-northwest of the Olin plant. The valley is most prominent near the origin on the Route 38 South (W) traverse. Bedrock is also relatively deep below Eames Street leading west towards the Route 38 Intersection. Several other relative lows exist along the traverses, although none dip below the elevation of the valley at the Eames Street and Route 38 intersection.

4.0 CLOSING

The field procedures and interpretative methodologies used in this project are consistent with standard, recognized practices in geophysical investigations. This warranty is in lieu of all other warranties either implied of expressed. **LGI** assumes no responsibility for interpretations made by others based on work performed by or recommendations made by **LGI**.

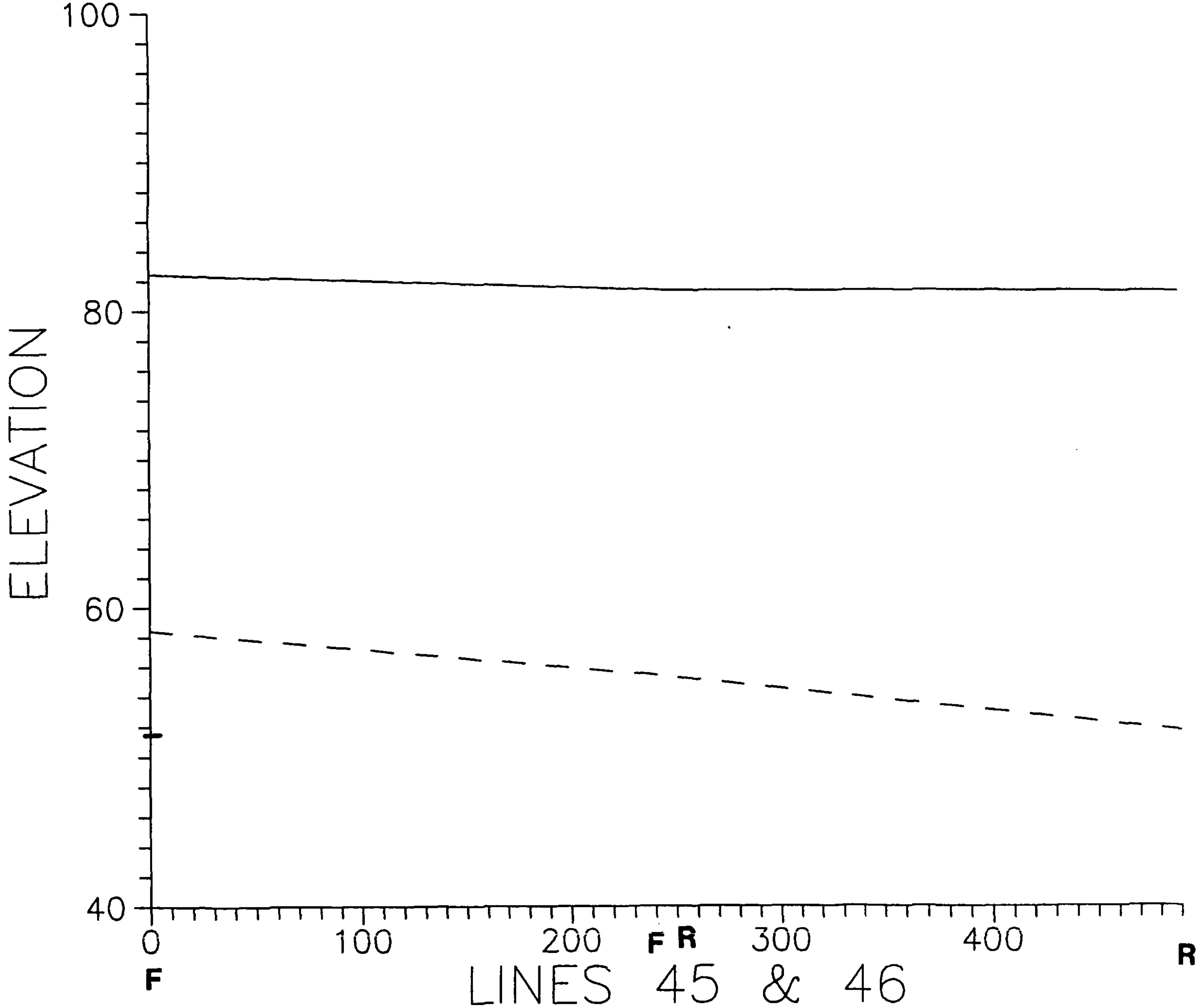
APPENDIX A

BEDROCK PROFILES

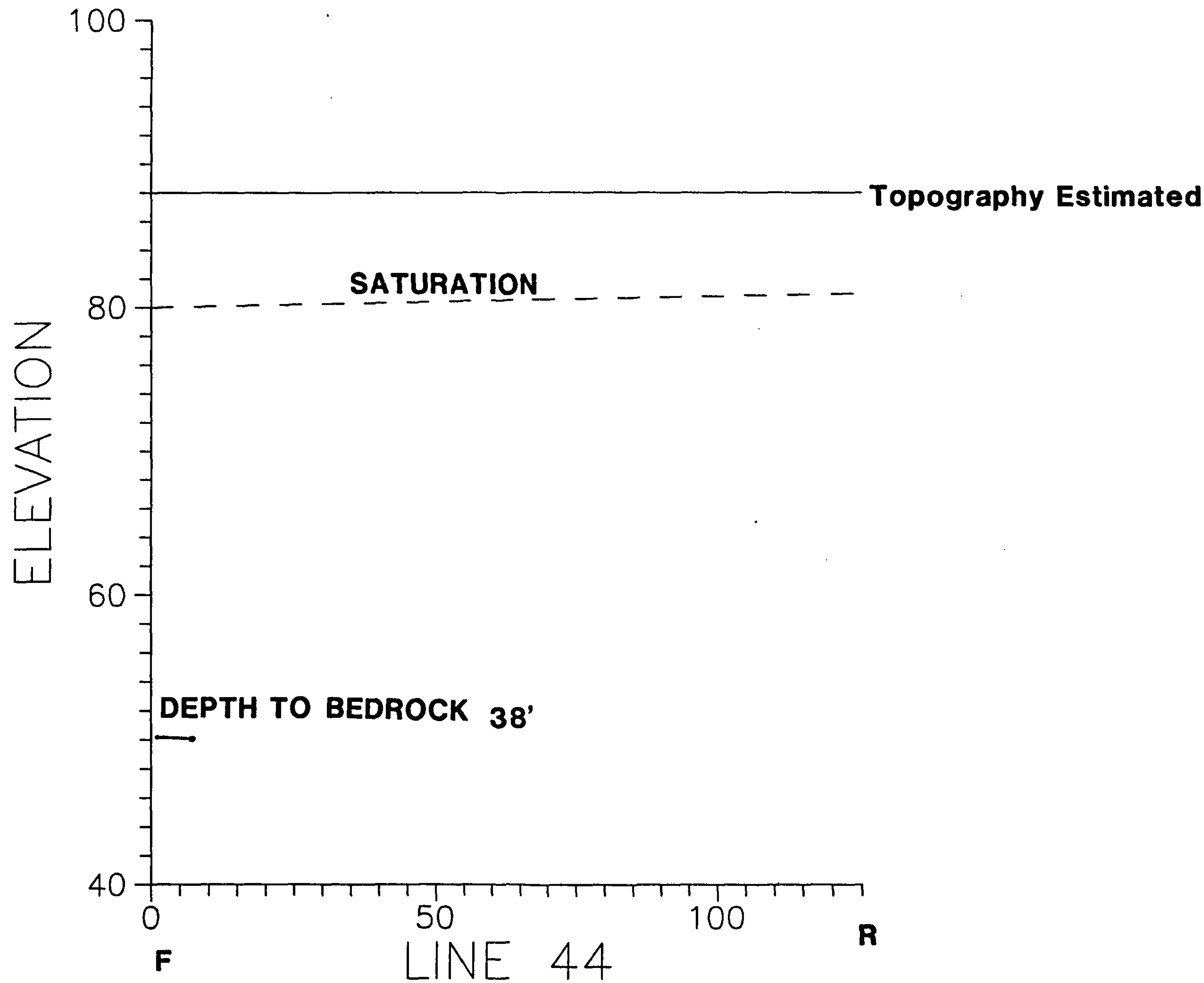
LEGEND

SOLID LINES: Existing Topography

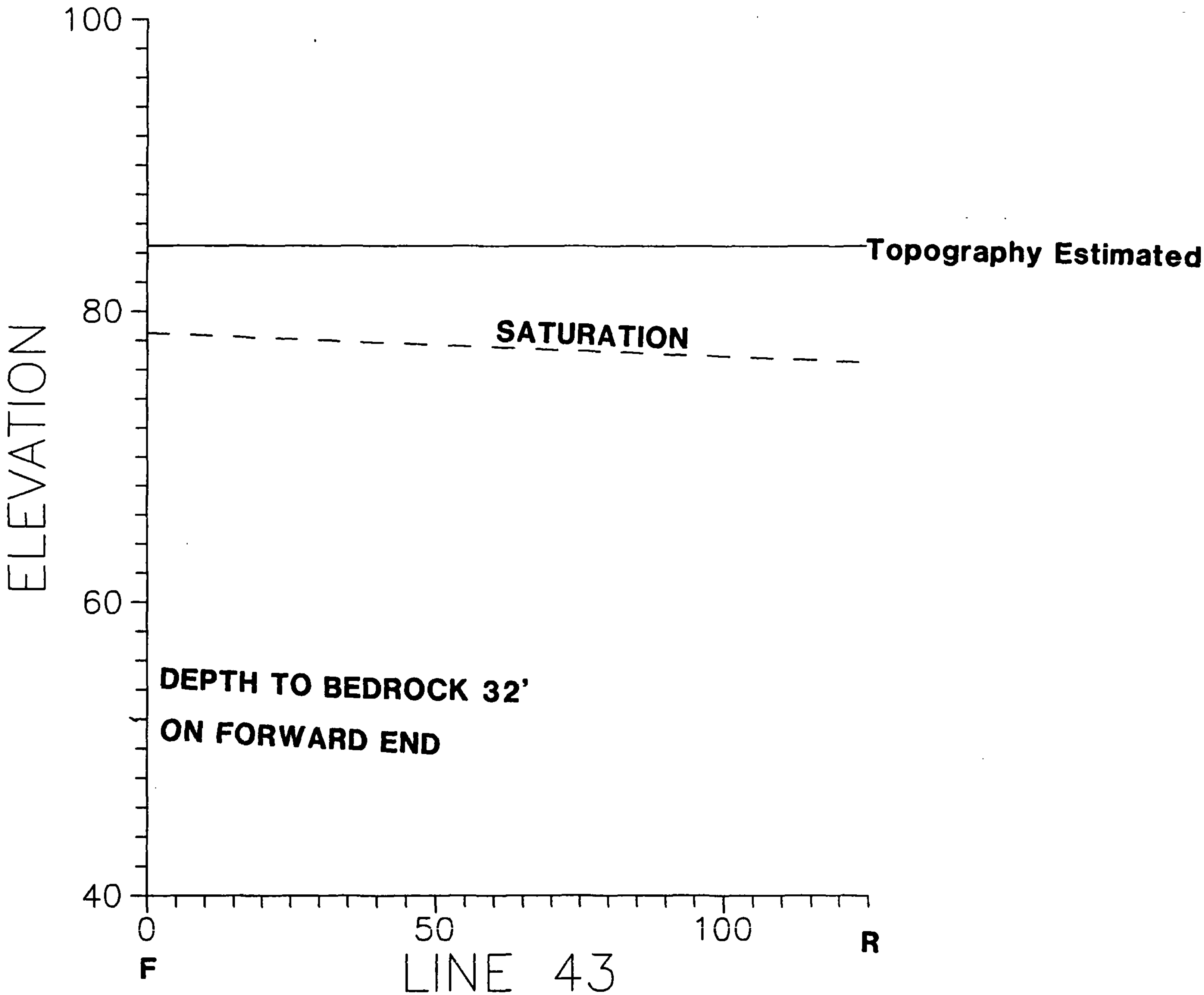
DASHED LINED: Bedrock Surface (unless noted otherwise)



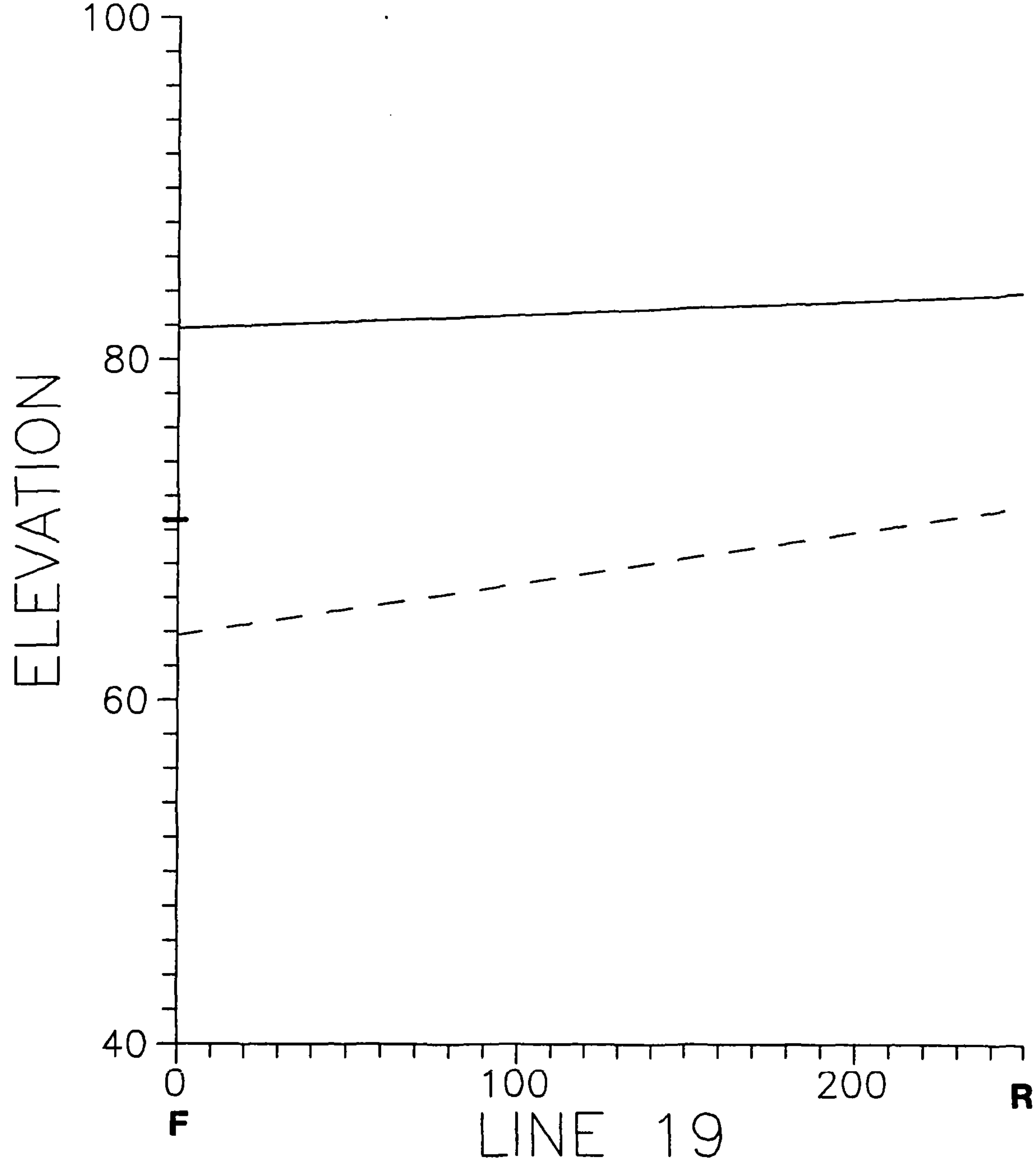
100
80
60
40
ELEVATION
0
100
200
300
400
F
F
R
R
LINES 45 & 46

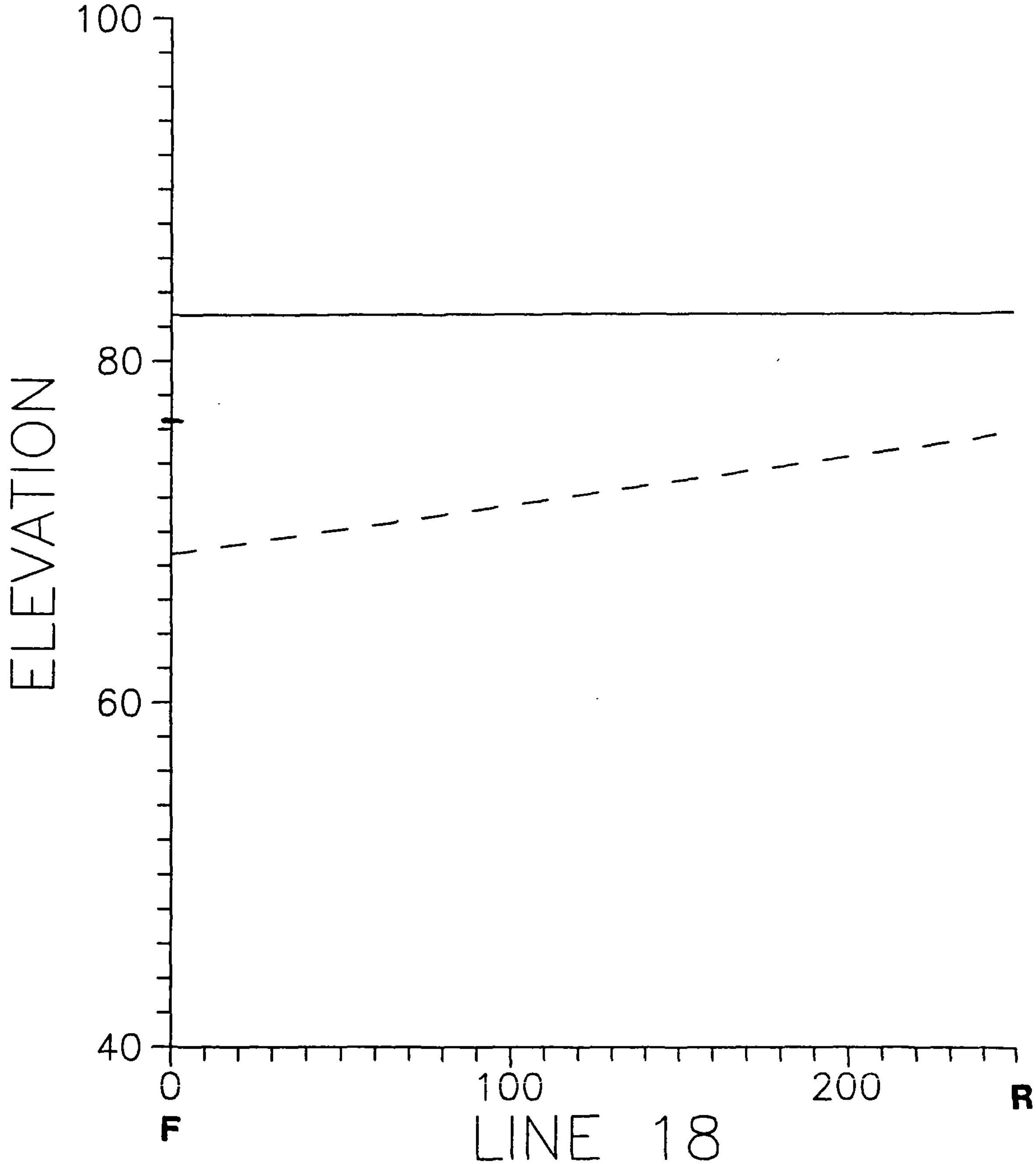


Topography Estimated
SATURATION
DEPTH TO BEDROCK 38'
ELEVATION
100
80
60
40
0
50
100
F
R
LINE 44

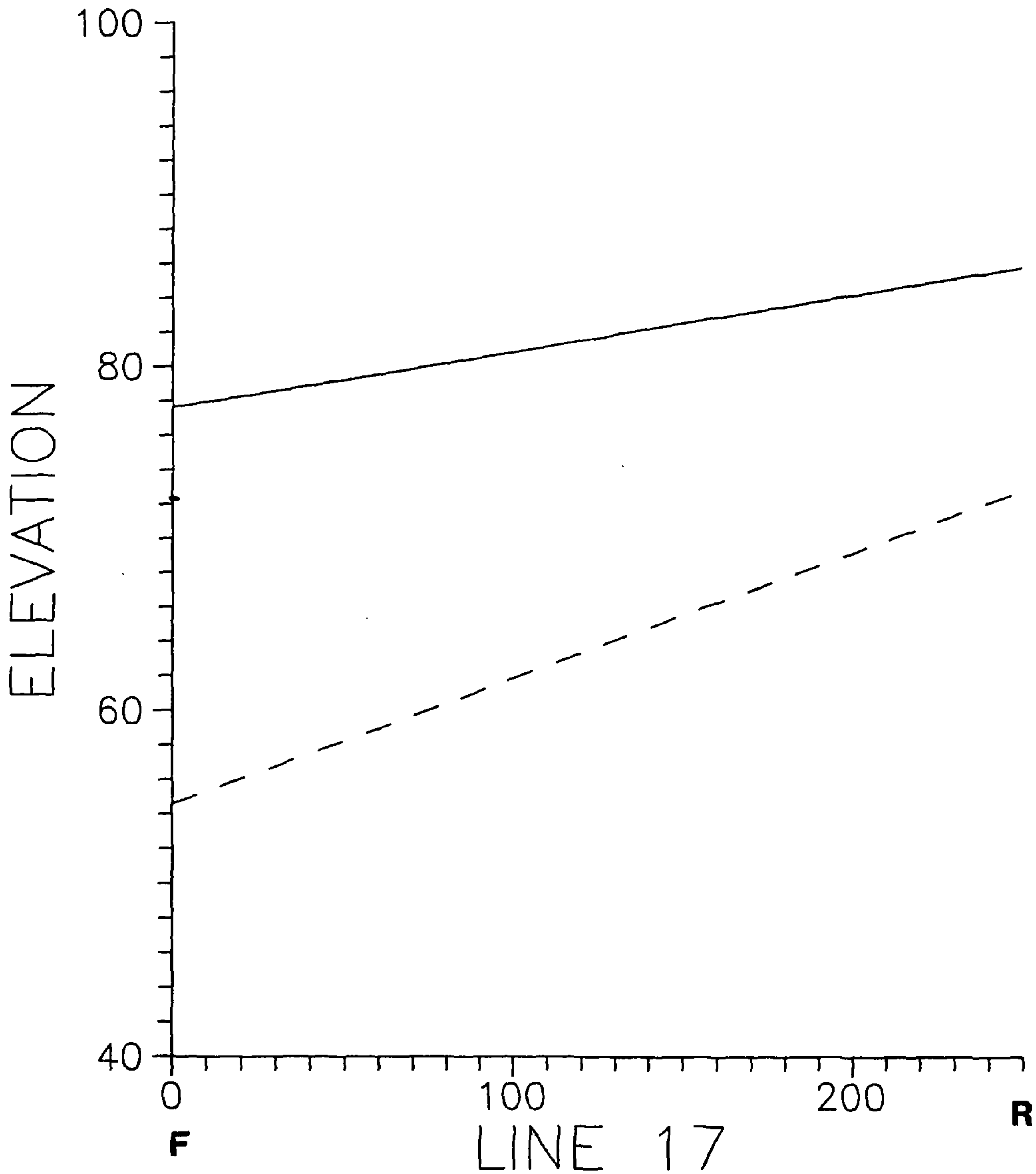


100
80
60
40
ELEVATION
Topography Estimated
SATURATION
DEPTH TO BEDROCK 32'
ON FORWARD END
0
50
100
F
R
LINE 43

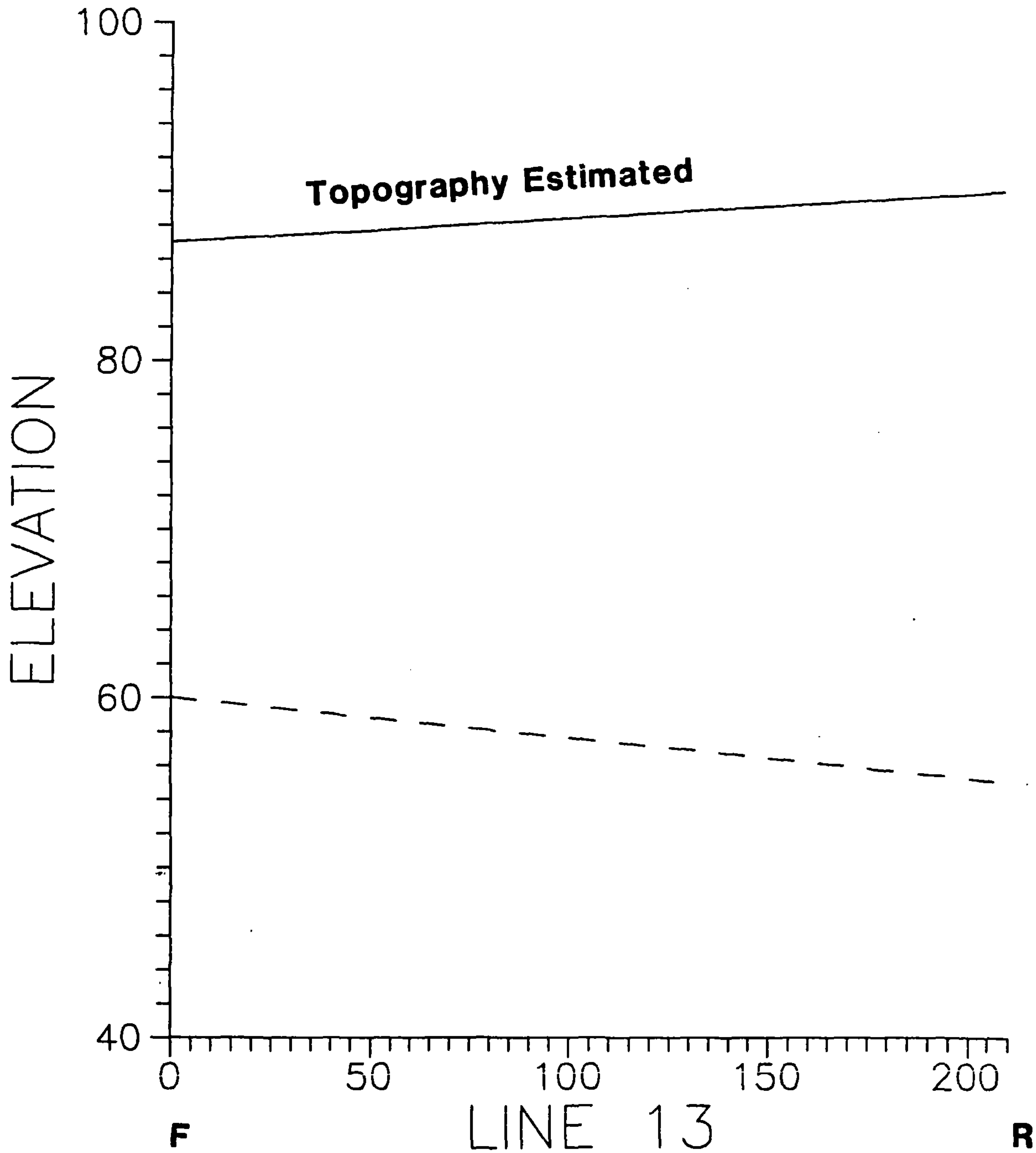

100
80
60
40
ELEVATION
0
100
200
F
R
LINE 19



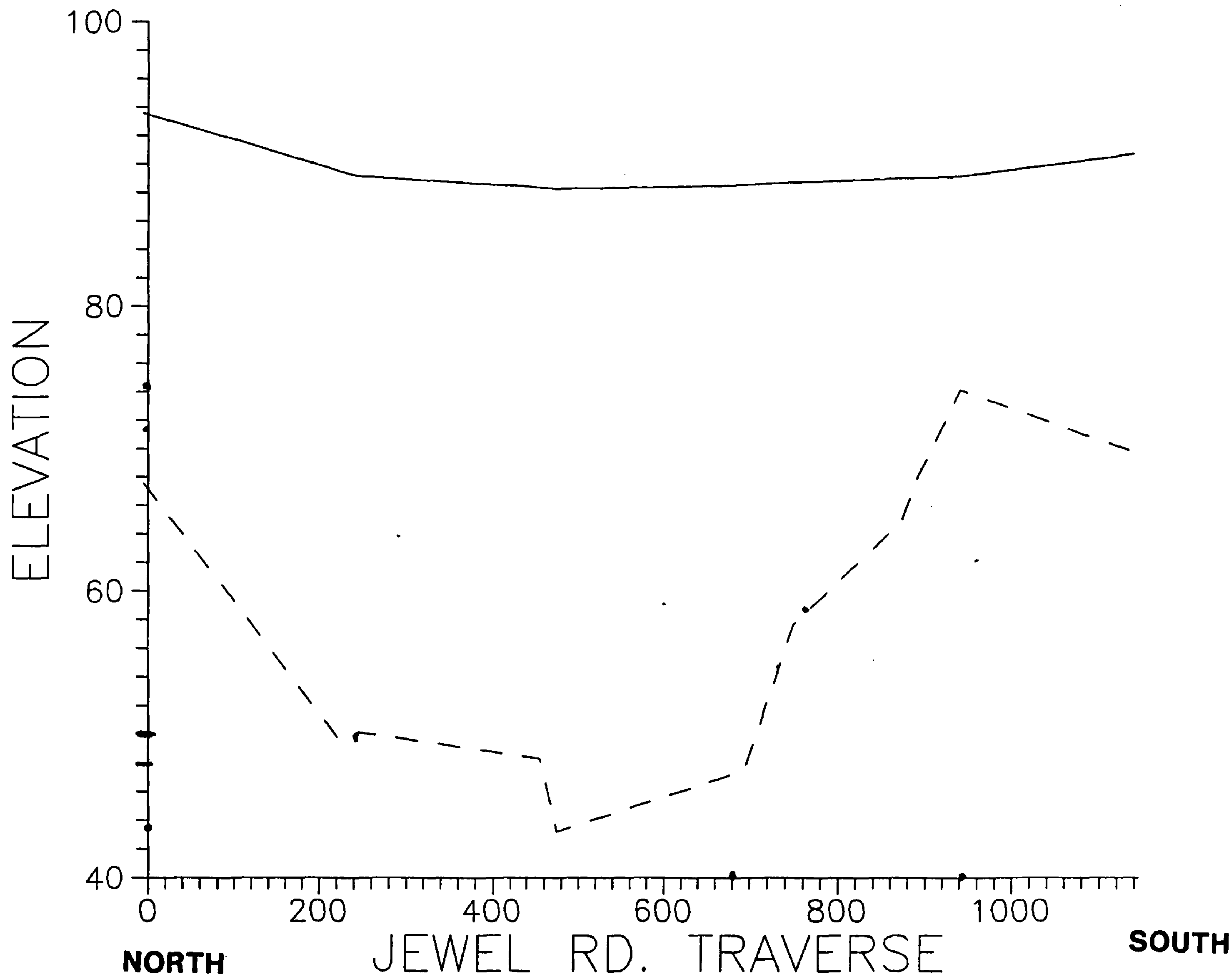
100
80
60
40
ELEVATION
0
100
200
F
R
LINE 18



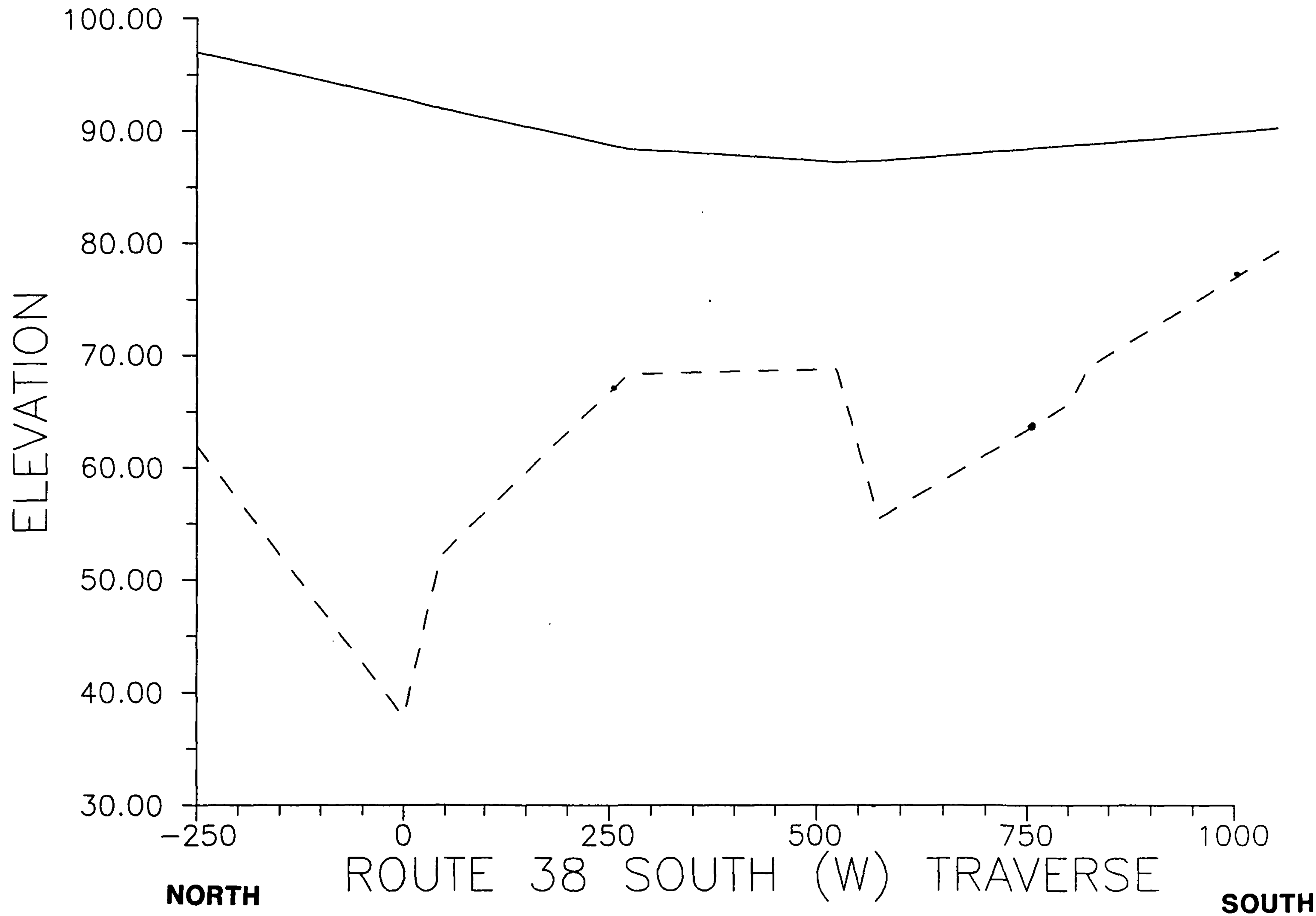
100
80
60
40
ELEVATION
0
100
200
F
R
LINE 17



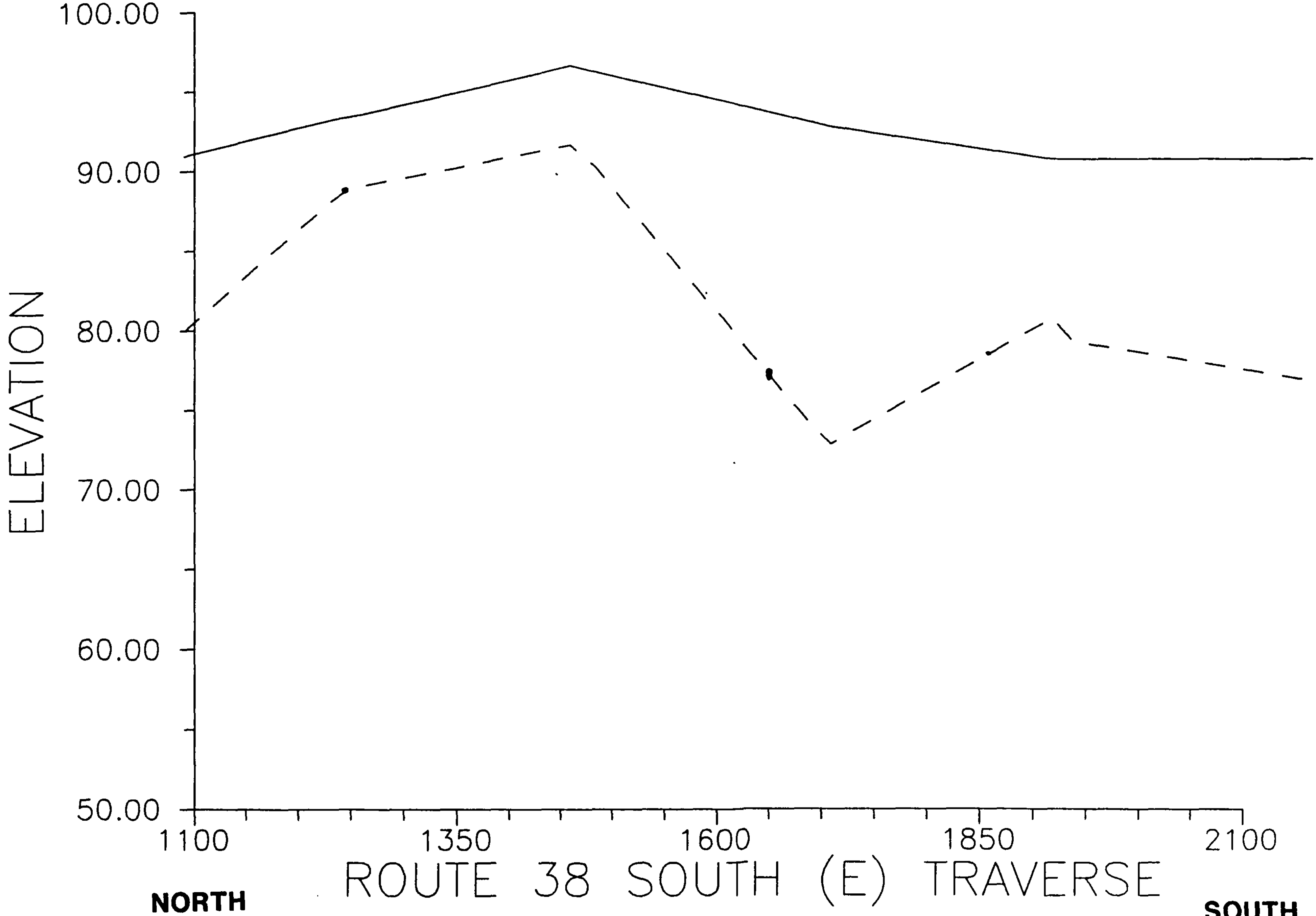
Topography Estimated
100
80
60
40
ELEVATION
0
50
100
150
200
F
LINE 13
R



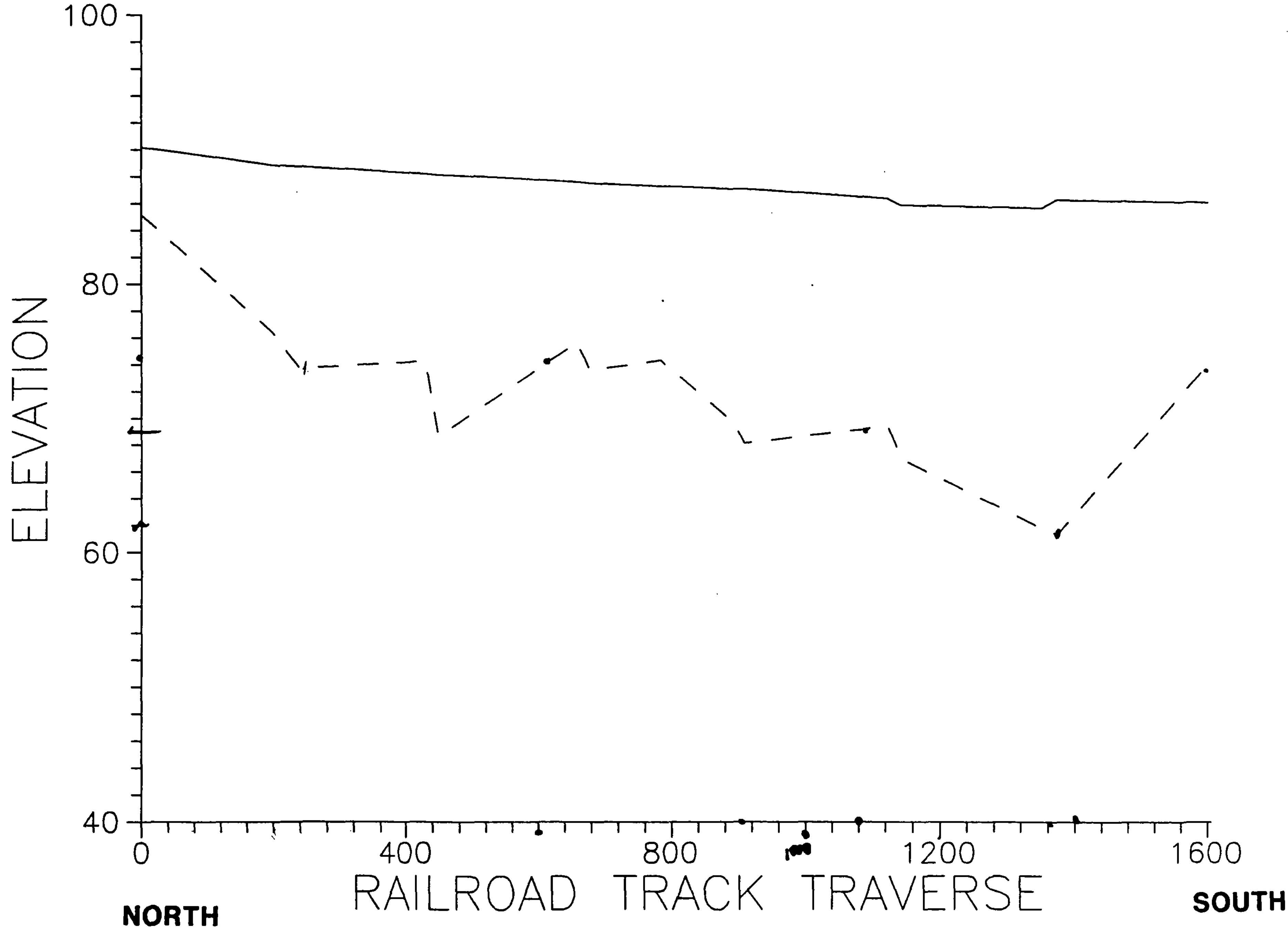
100
80
60
40
ELEVATION
0
200
400
600
800
1000
NORTH
JEWEL RD. TRAVERSE
SOUTH

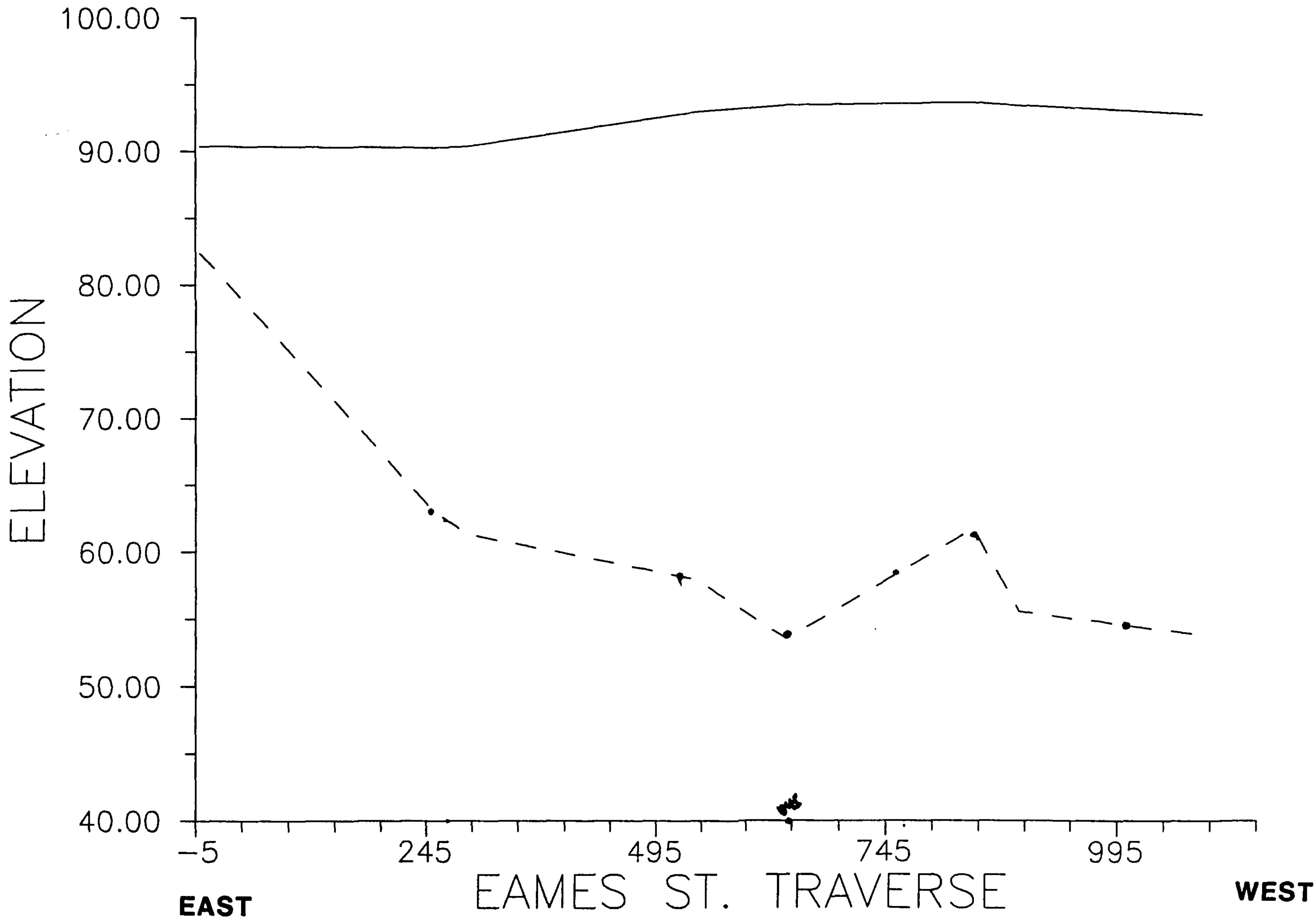


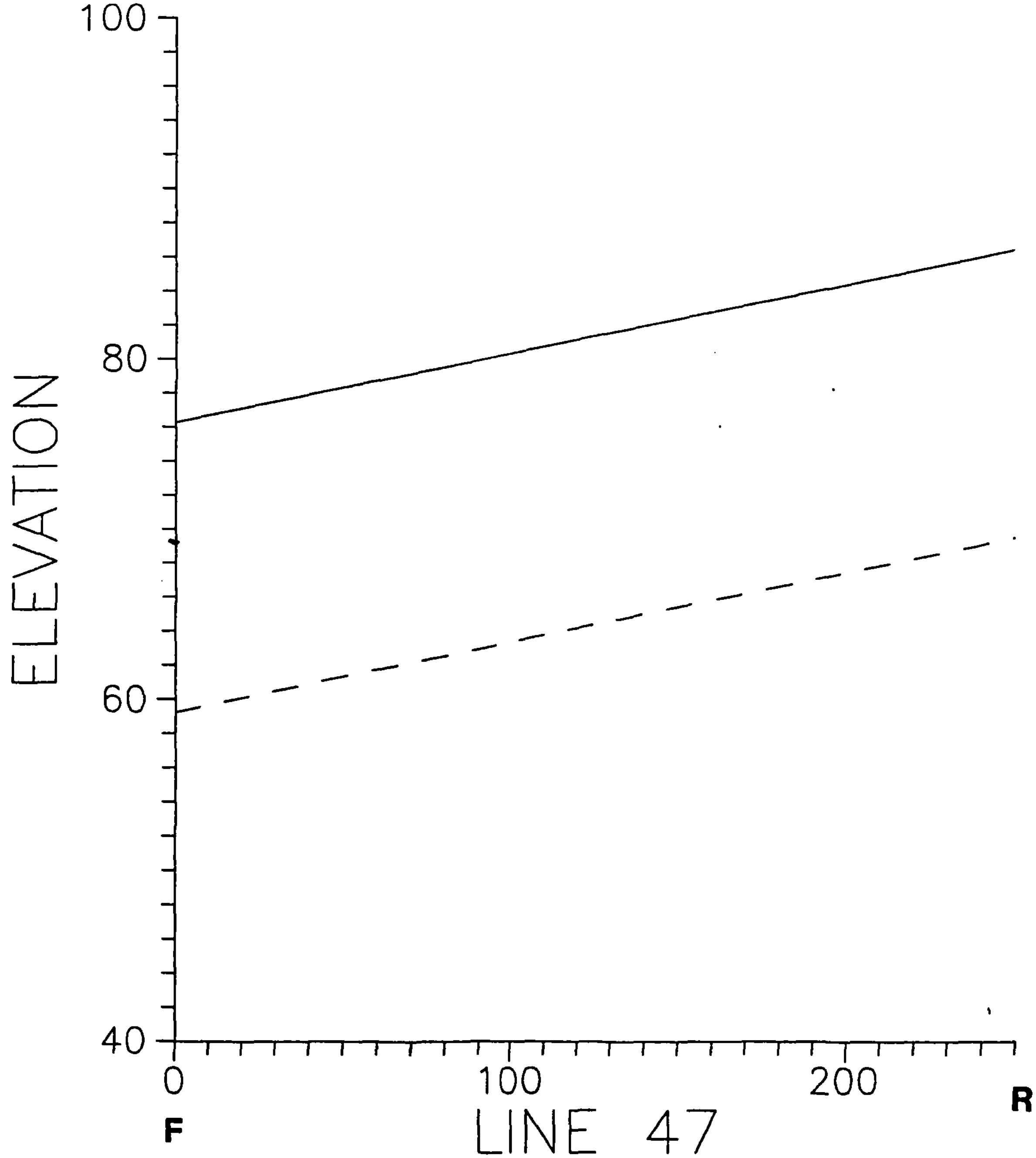
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
ELEVATION
−250
0
250
500
750
1000
ROUTE 38 SOUTH (W) TRAVERSE
NORTH
SOUTH



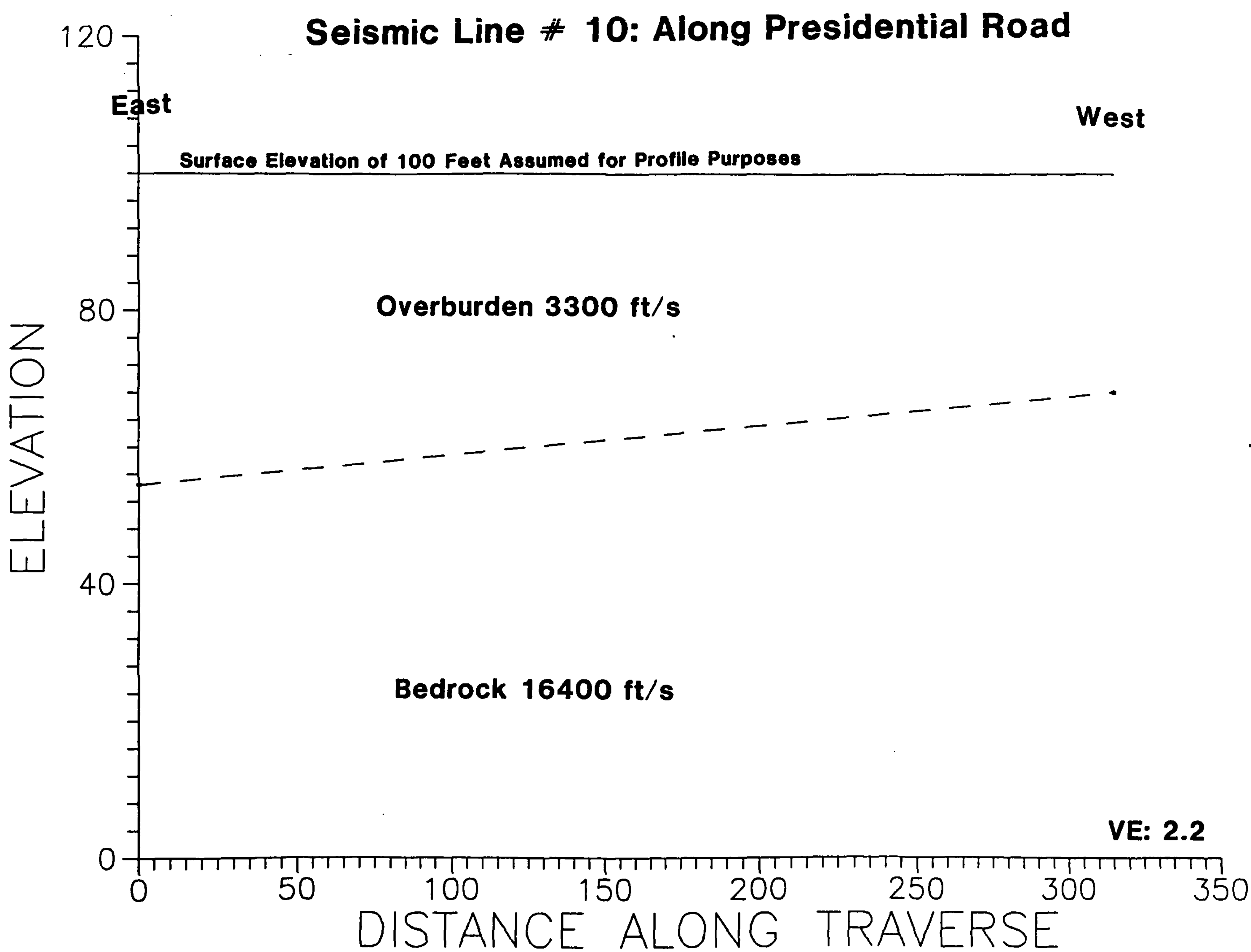
100.00
90.00
80.00
70.00
60.00
50.00
ELEVATION
1100
1350
1600
1850
2100
ROUTE 38 SOUTH (E) TRAVERSE
NORTH
SOUTH

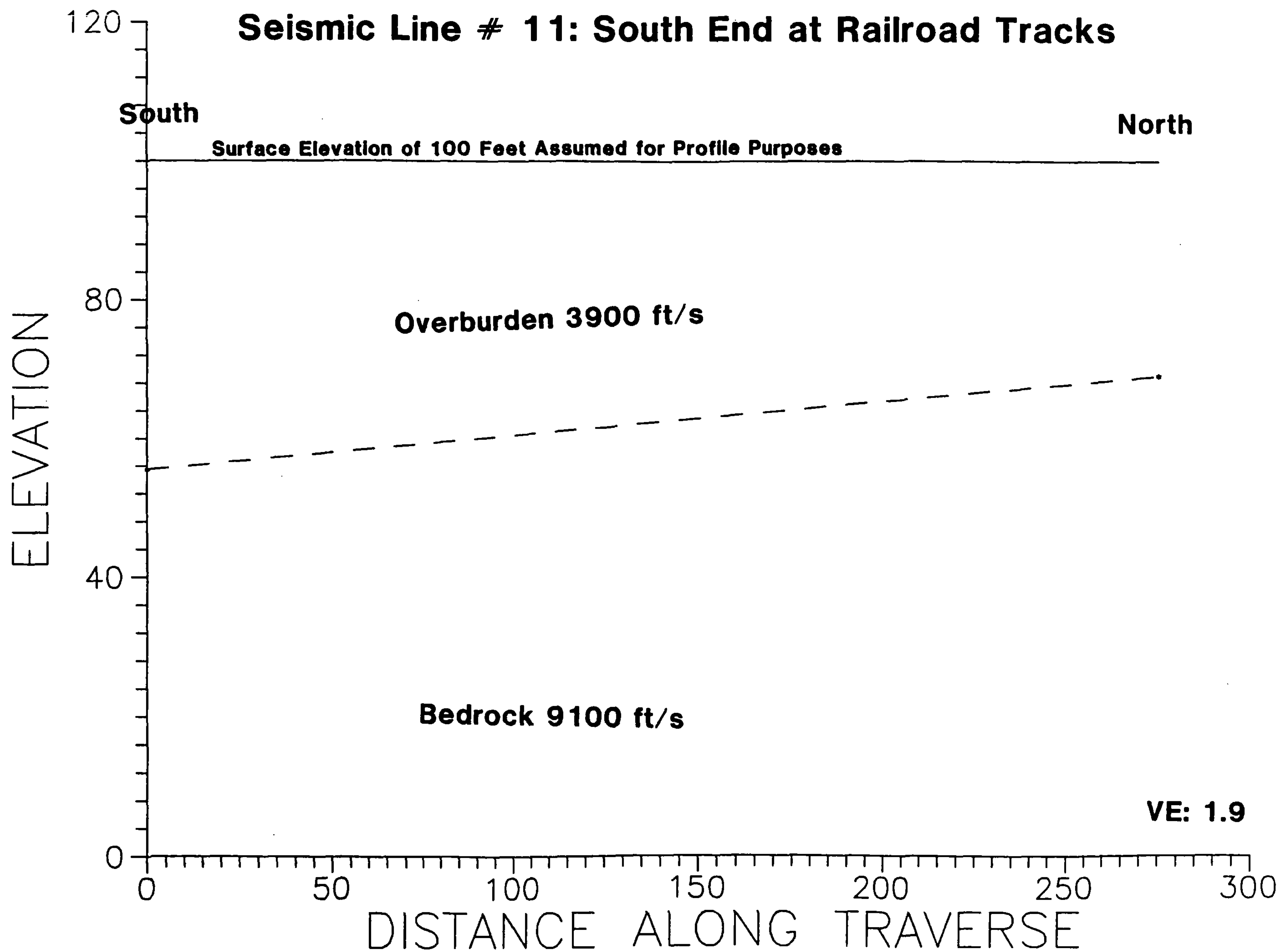

100
80
60
40
ELEVATION
0
400
800
1200
1600
RAILROAD TRACK TRAVERSE
NORTH
SOUTH


100.00
90.00
80.00
70.00
60.00
50.00
40.00
ELEVATION
-5
245
495
745
995
EAST
EAMES ST. TRAVERSE
WEST

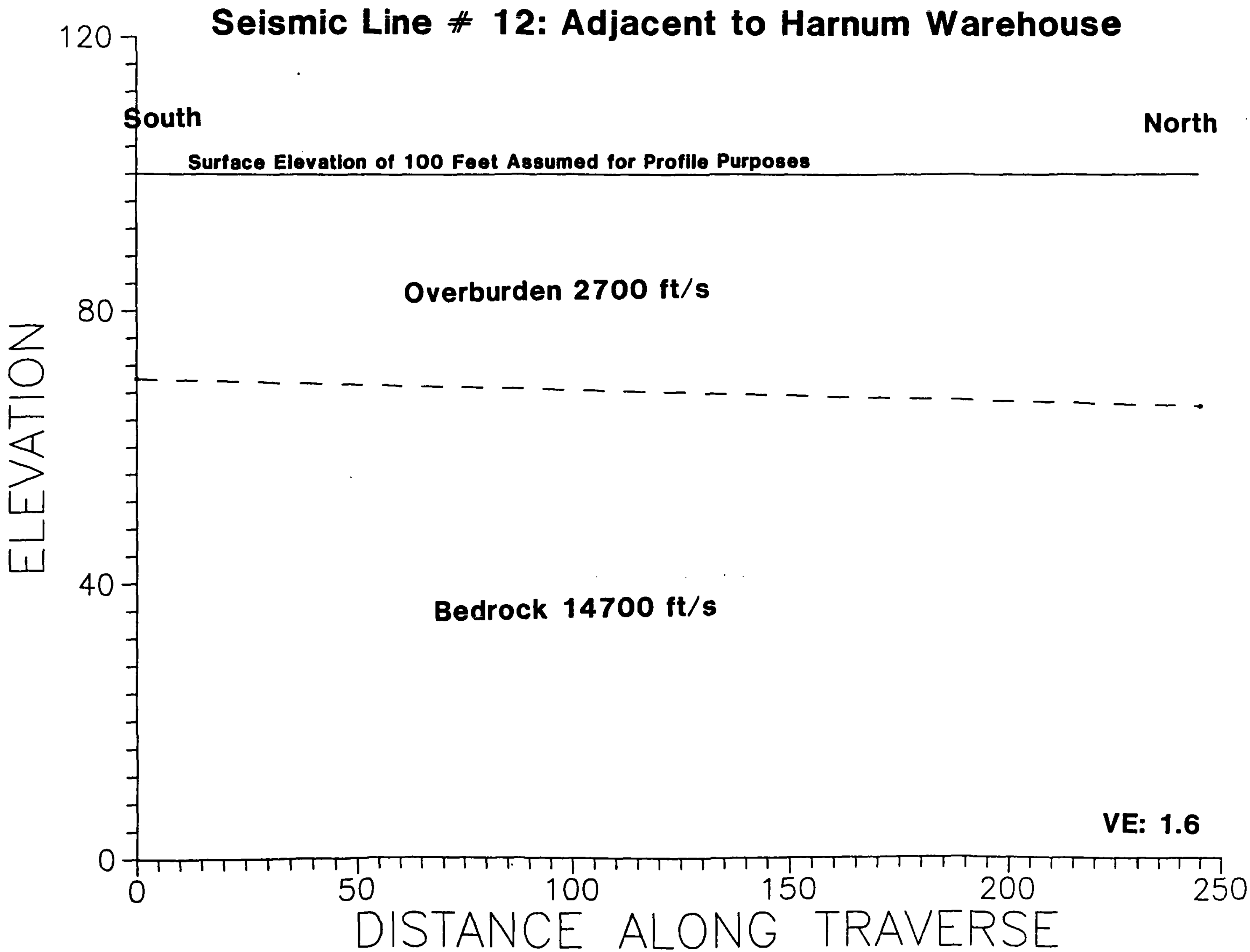


100
80
60
40
ELEVATION
0
100
200
F
R
LINE 47


Seismic Line # 10: Along Presidential Road
East
West
Surface Elevation of 100 Feet Assumed for Profile Purposes
Overburden 3300 ft/s
Bedrock 16400 ft/s
VE: 2.2
ELEVATION
120
80
40
0
0
50
100
150
200
250
300
350
DISTANCE ALONG TRAVERSE



Seismic Line # 11: South End at Railroad Tracks
South
North
Surface Elevation of 100 Feet Assumed for Profile Purposes
Overburden 3900 ft/s
Bedrock 9100 ft/s
VE: 1.9
ELEVATION
120
80
40
0
0
50
100
150
200
250
300
DISTANCE ALONG TRAVERSE



Seismic Line # 12: Adjacent to Harnum Warehouse
South
North
Surface Elevation of 100 Feet Assumed for Profile Purposes
Overburden 2700 ft/s
Bedrock 14700 ft/s
VE: 1.6
ELEVATION
DISTANCE ALONG TRAVERSE
120
80
40
0
0
50
100
150
200
250